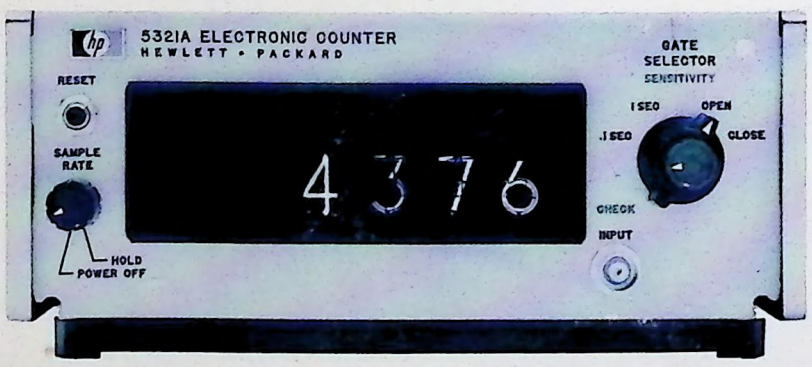
OPERATING AND SERVICE MANUAL

ELECTRONIC COUNTERS

5221A AND 5321A



HEWLETT hp PACKARD

HP 5221A/5321A

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

ELECTRONIC COUNTERS
5221A and 5321A

5221A SERIALS PREFIXED: 740-

This manual applies directly to HP Model 5221A Electronic Counters having serial prefix number 740.

5321A SERIALS PREFIXED: 808-

This manual applies directly to HP Model 5321A Electronic Counters having serial prefix number 808.

OLDER INSTRUMENTS

The changes required to backdate this manual for older instruments can be found in Section VII.

OPTIONS

For instruments having options 01, 02, or 10 refer to Section VII.

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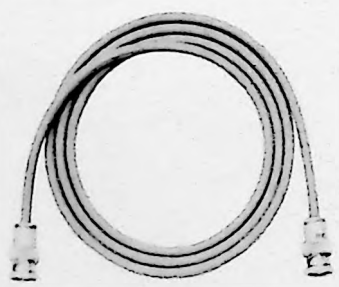
Figure 1-1. Models 5221A and 5321A and Accessories Supplied

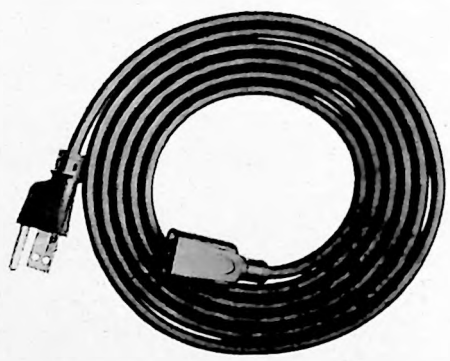
MODEL 5221A

MODEL 5321A

BNC TO BNC CABLE



POWER CORD



SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION

1-2. The Hewlett-Packard Model 5221A or 5321A Electronic Counter measures frequencies from 5 Hz to 10 MHz. Models 5221A and 5321A are similar. The main differences being size and shape.

1-3. The counters provide these additional features:

a. Blanking of unwanted zeros in the display (zeros left of the most significant digit).

b. Display storage holds the display while a new count is being made.

c. Remote gate control through BNC connector on rear panel.

1-4. The counters feature solid state design incorporating HP integrated circuits.

1-5. SPECIFICATIONS

1-6. Table 1-3 outlines the technical specifications for Models 5221A and 5321A Electronic Counters.

1-7. APPLICATIONS

1-8. The counters can measure speed, rpm, rps, and count events occuring within a selected period of time. With transducers converting mechanical to electrical phenomena, weight, pressure, temperature, acceleration and other quantities can be measured.

1-9. OPTIONS

1-10. The counters are available with the following options:

a. 5 digit display (Option 01).

b. 6 digit display (Option 02).

c. Operation from 50 Hz power line (Option 10).

1-11. INSTRUMENT IDENTIFICATION

1-12. Each instrument is identified by a two-section, eight-digit (xxx-xxxxx) serial number on the rear panel. The five-digit number is an identification number unique to each instrument, and the three-digit number is a serial prefix number used to document changes.

1-13. All instruments with the same serial prefix are the same. The group of instruments to which this manual applies directly is identified on the title page. For older instruments (lower serial numbers) make manual changes listed in Section VII. For newer instruments, having serial numbers higher than those listed on the title page, a Manual Changes sheet is included, describing the required manual changes. The manual for an instrument having special electrical modifications will include an insert sheet describing that modification. If a change sheet or special information sheet is missing, the information can be supplied on request by any Hewlett-Packard Sales and Service office listed at the back of this manual.

1-14. EQUIPMENT SUPPLIED

1-15. Equipment supplied with the Model 5221A and 5321A is listed in Table 1-1.

1-16. ACCESSORIES AVAILABLE

1-17. Accessories available for the Model 5221A and 5321A are listed in Table 1-2.

Table 1-1. Equipment Supplied

Description	HP Part No.
Detachable power cord 7-1/2 feet (231 cm) long; NEMA plug.	8120-0078
Cable: 4 feet (122 cm) long, male BNC connectors.	10503A

Table 1-2. Accessories Available

Description	HP Part No.
Rack mount adapter frame (5221A)	5060-0797
Rack mount adapter frame (5321A).	5060-0808
Combining Case (used for both)	1052A

Table 1-3. Specifications

RANGE: 5 Hz to 10 MHz

REGISTRATION: 4 digits (5 and 6 available); long-life display tubes with storage.

MAXIMUM DISPLAYED FREQUENCY:
Standard model: 99.99 kHz
Option 01: 999.99 kHz
Option 02: 9.99999 MHz (decimal point and units are not displayed).

INPUT
Maximum Sensitivity: 0.1 V rms sine wave from 5 Hz to 10 MHz.

Pulses: 300 mV peak voltage (internal control adjusts for positive or negative pulses), 50 ns minimum pulse width.

Impedance: Approximately 1 megohm shunted by 50 pF.

Overload: At maximum sensitivity, input should not exceed 3.5V rms to maintain rated input impedance. Damage level is 15V rms. At min. sensitivity damage level is 250V rms.

ACCURACY: ±1 count ± power line frequency accuracy.*

TIME BASE: Frequency: 60 Hz power line frequency (50 Hz optional).

SELF CHECK: Counts power line frequency. Option 10 counts twice power line frequency (100 Hz).

GATE TIMES: 1 and 0.1 sec.

---

* Line Frequency is typically ±.1% for domestic utility systems.

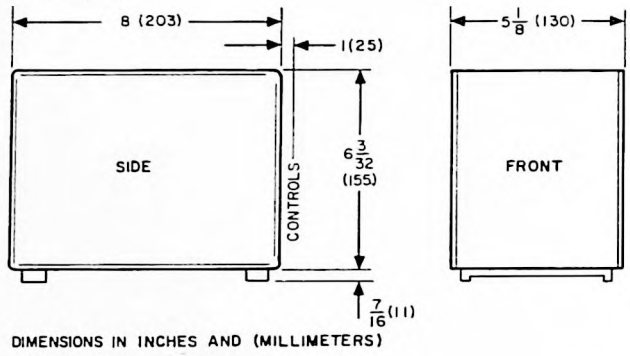
GATE CONTROL: With GATE SELECTOR switch on front panel, by contact closure, or saturated NPN transistor ground at EXT GATE jack on rear panel with GATE SELECTOR in OPEN position.

DISPLAY TIME: Variable from 50 ms to approx. 5 s, or may be held until manually reset.

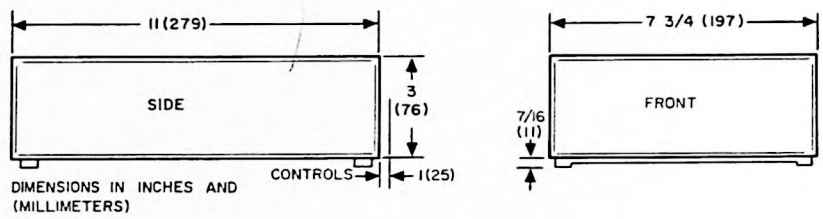
OPERATING TEMPERATURE: 0°C to +50°C.

WEIGHT: Net, 5 lbs (2,3 kg);
Shipping, 6-1/2 lbs (3,0 kg).

DIMENSIONS:



DIMENSIONS IN INCHES AND (MILLIMETERS)



DIMENSIONS IN INCHES AND (MILLIMETERS)

POWER REQUIREMENTS: 115 or 230 V ±10%, 60 Hz (50 Hz Option 10) 12 W.

ACCESSORIES SUPPLIED: Detachable power cord and BNC to BNC cable.

OPTIONS: Option 01 (5 digit display)
Option 02 (6 digit display)
Option 10 (50 Hz operation)

SECTION II

INSTALLATION

2-1. UNPACKING AND INSPECTION

2-2. If the shipping carton is damaged, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for damage (dents, scratches, broken knobs, etc.). If the instrument is damaged or fails to meet specifications, (Performance Check, Paragraph 5-9), notify the carrier and the nearest Hewlett-Packard Sales and Service office immediately (offices are listed at the back of this manual). Retain the shipping carton and the padding material for the carrier's inspection. The Sales and Service office will arrange for the repair or replacement of the instrument without waiting for the claim against the carrier to be settled.

2-3. STORAGE AND SHIPMENT

2-4. To protect valuable electronic equipment during storage or shipment always use the best packing methods available. Your Hewlett-Packard Sales and Service office can provide packing material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are two recommended packaging methods:

2-5. RUBBERIZED HAIR. Cover painted surfaces of the instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/sq in bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a firm fit.

2-6. EXCELSIOR. Cover painted surfaces of the instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq in bursting test) with a layer of excelsior about 6 inches thick packed firmly against all surfaces of instrument.

2-7. ENVIRONMENT. Conditions during storage and shipment should be limited as follows:

a. Maximum temperature: +167°F (+75°C).

b. Minimum temperature: -40°F (-40°C).

2-8. RACK INSTALLATION

2-9. When the instrument is to be rack-mounted, a combining case or adapter frame is required. These are available through the Hewlett-Packard Sales and Service offices. The following paragraphs outline the methods for rack mounting the 5221A and the 5321A.

2-10. MODEL 5221A

2-11. COMBINING CASE. The combining case (HP Part No. 1052A, Figure 2-1) is a unit which accepts three units of 5221A size. The combining case can be used as a bench model or it can be rack mounted. A rack mounting kit (HP Part No. 5060-0777) is supplied with the combining case. When only 1/3 or 2/3 of the case is used, a blank filler panel (HP Part No. 5060-0793) is available to enclose the unused portion.

2-12. ADAPTER FRAME. The adapter frame (HP Part No. 5060-0797) in Figure 2-1 is a rack frame that accepts three units of 5221A size. It can only be rack mounted. Install instruments in the adapter frame as follows:

a. Place adapter frame on edge of bench as shown in step 1 of Figure 2-1.

b. Stack units in frame as shown in step 2. Place spacer clamps between units (step 3).

c. Place two end spacer clamps (step 4) and push units into frame.

d. Insert screws on either side of frame (step 5) and tighten until units are tight in frame. The complete assembly is now ready for rack mounting.

2-13. MODEL 5321A

2-14. COMBINING CASE. The combining case (HP Part No. 1052A, Figure 2-1) is a unit which accepts four units of 5321A size. The combining case can be used as a bench model or it can be rack mounted. A rack mounting kit (HP Part No. 5060-0777) is supplied with the combining case. When only half the case is used, a blank filler panel (HP Part No. 5060-0794) is available to enclose the unused portion. If only one unit is placed in the combining case, a blank filler panel (HP Part No. 5060-0097) is available to enclose the unused vertical area.

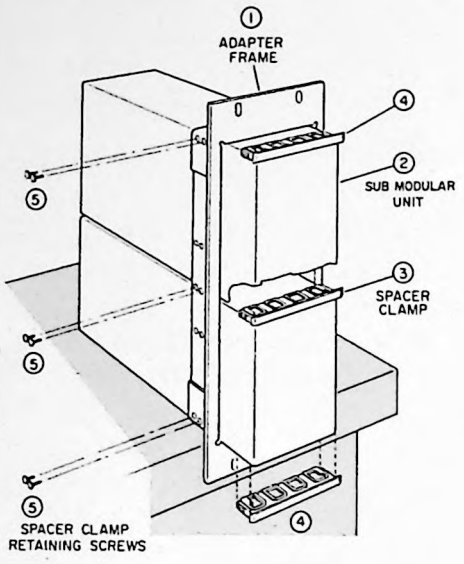
2-15. ADAPTER FRAME. The adapter frame (HP Part No. 5060-0808) similar to Figure 2-1 is a rack frame that accepts two units of 5321A size. It can only be rack mounted. Install the instruments in the adapter frame as follows:

a. Place adapter frame on edge of bench as shown in step 1 of Figure 2-1.

b. Stack units in frame as shown in step 2. Place spacer clamp between units, step 3.

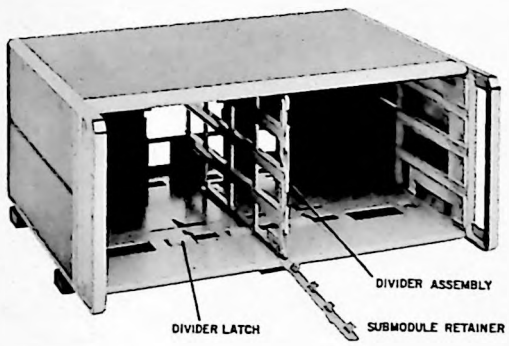
Figure 2-1. Adapter Frame and Combining Case

RACK ADAPTER FRAME

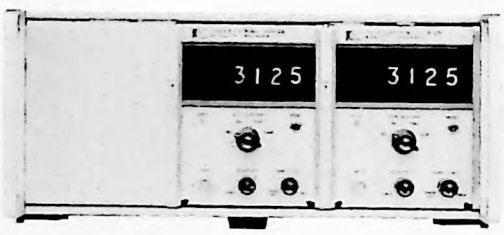


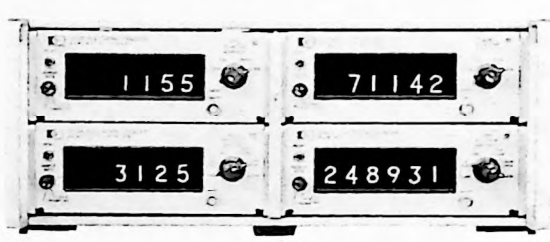
ALTERNATE COMBINATIONS

COMBINING CASE



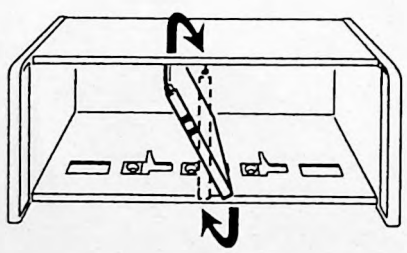
ALTERNATE COMBINATIONS



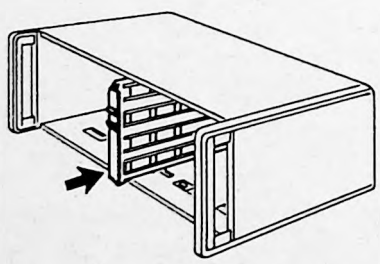


STEP (1)
SLIDE TOP PART TO LIMIT

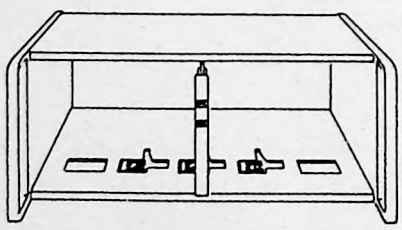
STEP (2)
SLIDE BOTTOM PART TO LIMIT



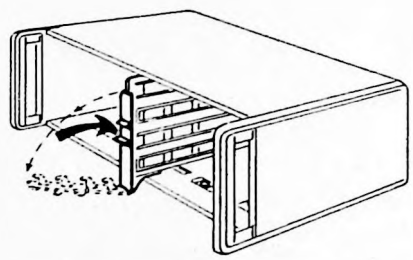
STEP (3)
PUSH IN TO LIMIT



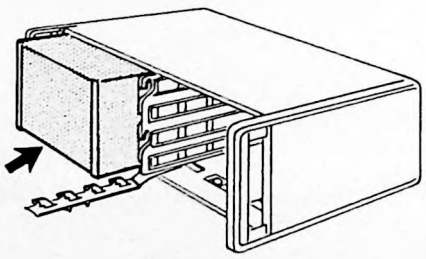
STEP (4)
SLIDE OVER TO LIMIT



STEP (5)
PUSH DOWN TO RELEASE

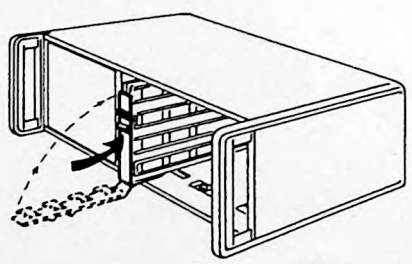


STEP (6)
PLACE INSTRUMENT INTO CASE



STEP (7)
SET RETAINER BACK INTO PLACE

STEP (8)
PUSH UP TO LOCK



ONE HALF MODULE SHOWN FOR TYPICAL INSTALLATION

c. Place two end spacer clamps (step 4) and push units into frame.

d. Insert screws on either side of frame, step 5, and tighten until units are tight in frame. The complete assembly is now ready for rack mounting.

2-16. OPERATION FROM 115 OR 230 VOLTS

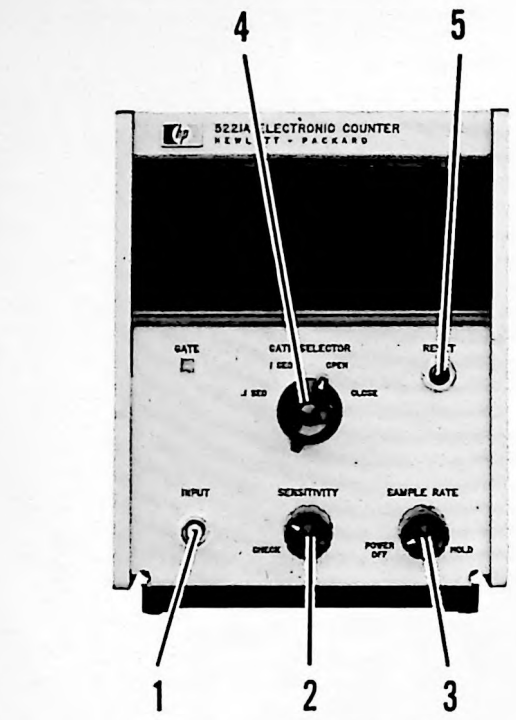
2-17. GENERAL. The instrument can be operated from either 115 or 230 Vac (60 Hz standard and 50 Hz Option 10) power lines. A slide switch on the rear panel permits quick conversion for operation from 115 or 230 Vac. Insert a narrow blade screwdriver in the switch slot and slide the switch to expose "115" marking for 115 volt operation or "230" marking for 230 volt operation. The ac line fuse is 0.25 ampere for 115 V and 0.15 ampere for 230 V operation.

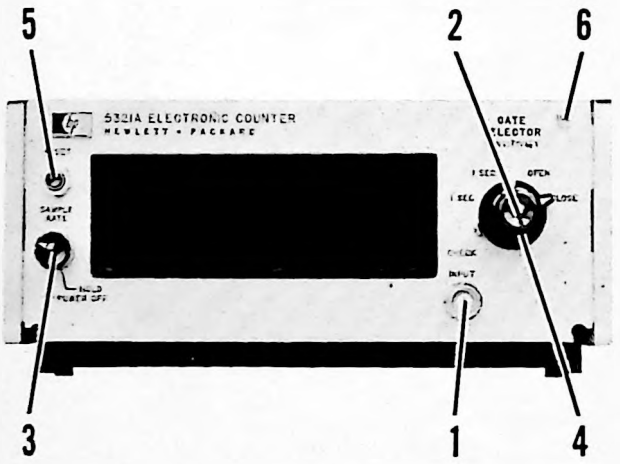
2-18. POWER CONNECTION. The instrument is supplied with a detachable 3-wire power cable. Install as follows:

a. Connect flat plug (3-conductor female connector) to the ac line jack at the rear of the instrument.

b. Connect plug (2-blade male with round grounding pin) to 3-wire grounded ac outlet. Exposed portions of the instrument are grounded through the round pin on the plug for safety. When only a 2-blade outlet is available, use HP adapter 1251-0048 and connect short wire from side of adapter to ground.

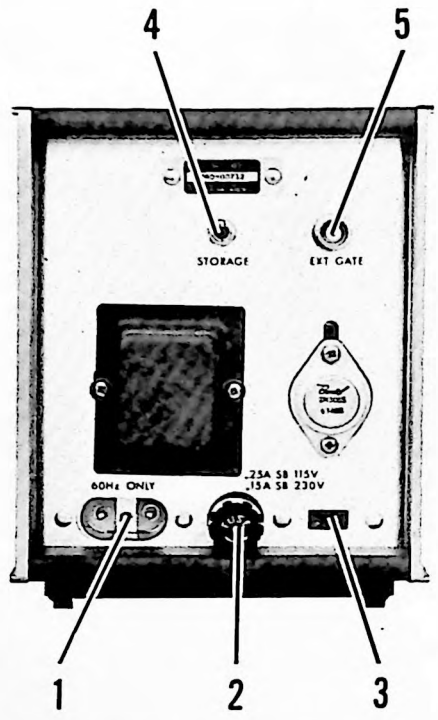
Figure 3-1. Front Panel Controls and Connectors

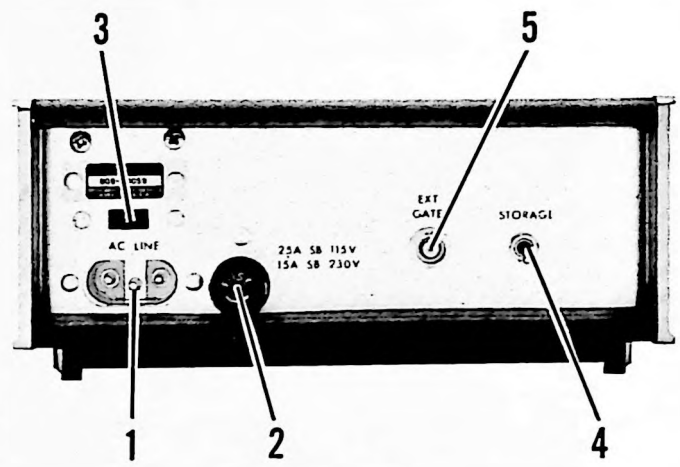




1. INPUT connector couples input signal to SENSITIVITY control.
2. SENSITIVITY connects CHECK signal to input amplifier or attenuated input signal.
3. SAMPLE RATE control turns counter on, holds display, and varies sample rate from 50 ms to 5 seconds.
4. GATE SELECTOR selects desired gate time or manual gate operation.
5. RESET switch manually resets counter.
6. GATE indicates gate open when light is on.

Figure 3-2. Rear Panel Controls and Connectors





1. AC LINE jack connects to flat plug on ac power cable.
2. LINE FUSE provides overload protection; should be .25 amp slow-blow for 115 V operation, and .15 amp slow-blow for 230 V operation.
3. LINE VOLTAGE permits selection of either 115 V or 230 V operation; insert narrow blade and slide left for 230V operation, right for 115V operation.
4. STORAGE switch controls storage and blanking feature.
5. EXT GATE provides external gate control by contact closure or saturated NPN transistor ground.

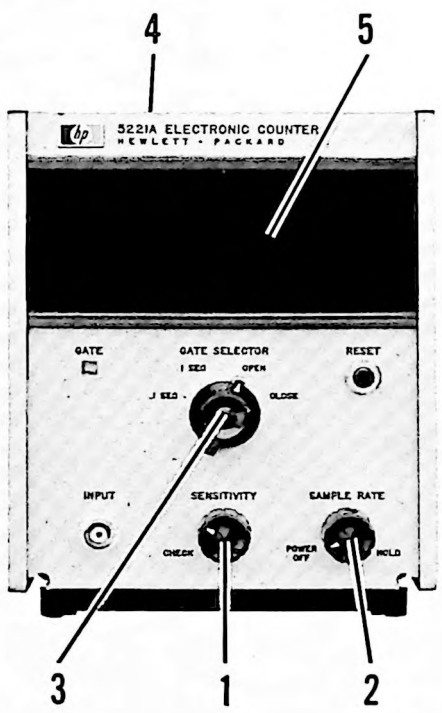
SECTION III

OPERATION

3-1. INTRODUCTION

3-2. The Counters have a maximum counting rate of 10 MHz and can measure the repetition rate of periodic signals by totalizing the events during gate times of 0.1 or 1 second. GATE SELECTOR switch selects measurement function and time base. SAMPLE RATE control selects the sampling rate and a SENSITIVITY control adjusts the instrument sensitivity. Figures 3-1 and 3-2 describe the operation of controls on the front and rear panels.

Figure 3-3. Self Check Function



1. Set SAMPLE RATE control for maximum sample rate (ccw, not off).
2. Set SENSITIVITY control to CHECK.
3. Set GATE SELECTOR switch to 1 SEC and .1 SEC.
4. Set STORAGE switch to on and repeat step 3.
5. The table below shows the proper count for each gate time setting for both the standard instrument (60 Hz) and Option 10 (50 Hz).

Gate Time	Standard (60 Hz Time Base)	Option 10 (50 Hz Time Base)
1 SEC	0060	0100
.1 SEC	0006	0010

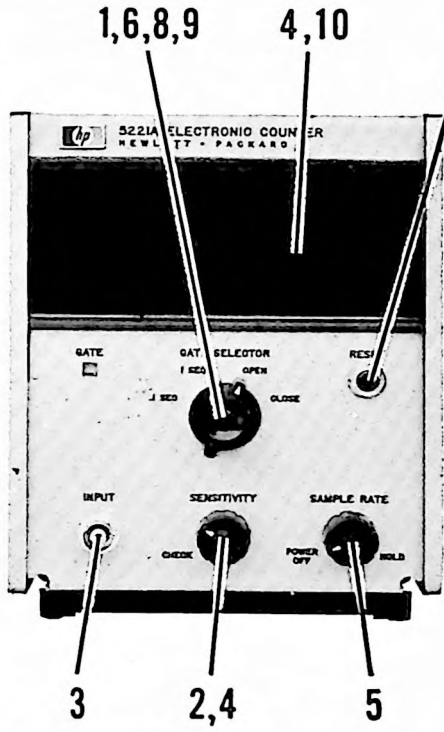
3-3. INTERPRETING DISPLAY

3-4. Display is in events per gate time. Decimal point and units are not displayed. With the GATE SELECTOR switch in the OPEN/CLOSE position, the display is read directly.

3-5. ACCURACY

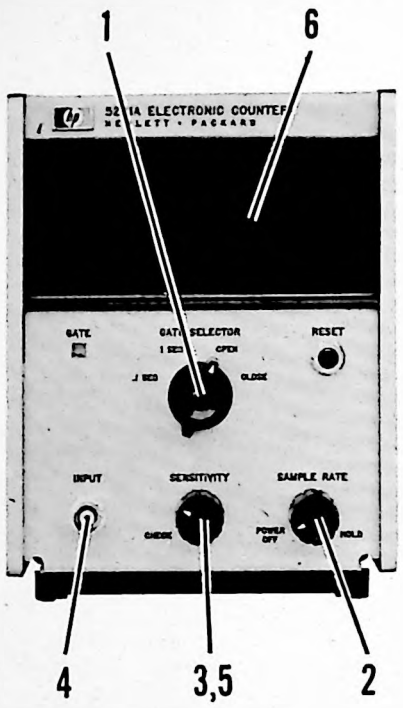
3-6. Counter accuracy is determined by the 50 or 60 Hz line time base accuracy (typically ±0.1% or better for domestic utility systems) and the inherent error of ±1 count present in all digital counters of this type.

Figure 3-4. Totalizing Operation



1. Set GATE SELECTOR switch to OPEN.
2. Set SENSITIVITY to minimum (ccw, not to CHECK).
3. Connect signal to INPUT jack.
4. Adjust SENSITIVITY until count is displayed. Set SENSITIVITY 30° clockwise beyond this point.
5. Set SAMPLE RATE to any position (not POWER OFF).
6. Set GATE SELECTOR to CLOSE.
7. Press RESET button to set display to zero.
8. To start count, set GATE SELECTOR to OPEN.
9. To stop count, set GATE SELECTOR to CLOSE.
10. Read total count displayed.

Figure 3-5. Frequency Measurement



1. Set GATE SELECTOR switch to desired gate time; 1 SEC or .1 SEC.

2. Set SAMPLE RATE control for desired sample rate.

3. Set SENSITIVITY to minimum (ccw).

4. Connect signal to INPUT jack.

5. Adjust SENSITIVITY until consistent count is displayed. Set SENSITIVITY 30° clockwise beyond this point.

6. Read frequency displayed.

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This section describes how the counters operate. A discussion of logic fundamentals is given to aid understanding how integrated circuits work. Each assembly is discussed in order of its assembly designation. Schematic diagrams are included in Section VIII, Circuit Diagrams.

4-3. GENERAL DESCRIPTION

Block Diagram Figure 8-2

4-4. Frequency range is from 5 Hz to 10 MHz with a maximum sensitivity of 100 millivolts. The counter includes 3 printed circuit assemblies:

1) Input Amplifier A1 provides amplification and triggering for the main gate.

2) Main Board Assembly A2 consists of the following circuits:

   a. Time base dividers.
   b. Main gate and driver for decade counter assemblies.
   c. Sample rate multivibrator.
   d. Reset control.
   e. Transfer multivibrator for storage and non-storage.
   f. Integrated circuit decade counters, buffer storage units, and decoder-drivers for digital display tubes.

3) Power Supply Assembly A3.

4-5. GATING AND LOGIC

4-6. The counters use many integrated circuits. Therefore it is necessary to understand basic logic symbols and their application in gating. In the circuit diagrams, AND gate and OR gate symbols are used. The following paragraphs and illustrations introduce logic symbols and their applications.

4-7. Logic Symbols

4-8. The symbol shown in Figure 4-1A is for the basic AND gate function. AND gate output is high if all inputs are high. The AND gate can have two or more inputs. The symbol in Figure 4-1D is for the basic OR gate. The OR gate output is high when one or more of its inputs is high. The OR gate can have two or more

Figure 4-1. Gate Symbols

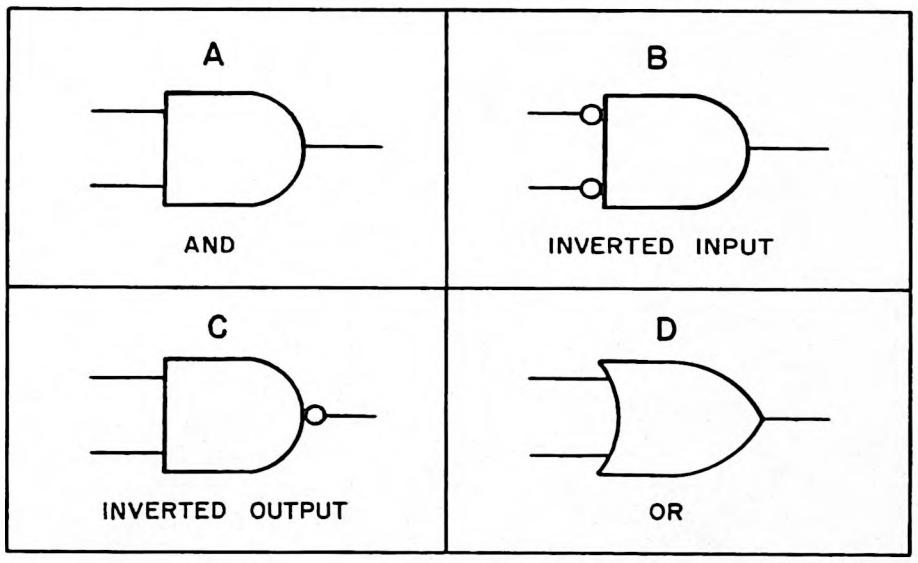
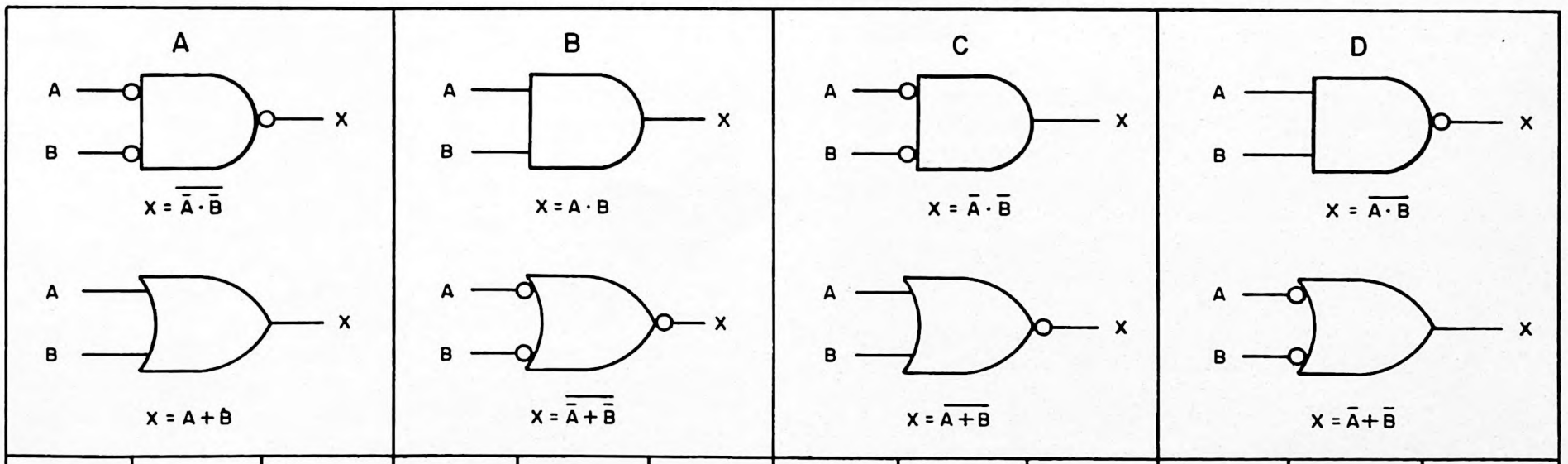


Figure 4-2. Logic Comparison Diagrams



A	B	X	A	B	X	A	B	X	A	B	X
H	H	H	H	H	H	H	H	L	H	H	L
H	L	H	H	L	L	H	L	L	H	L	H
L	H	H	L	H	L	L	H	L	L	H	H
L	L	L	L	L	L	L	L	H	L	L	H

inputs. A small circle at the input line of a logic symbol indicates a low (L) level activates the function. The symbol in Figure 4-1B shows a low input on all lines causes a high (H) level output. A small circle at the output line of a logic symbol indicates a low (L) level when activated, as shown in Figure 4-1C. Thus a small circle indicates inversion. This applies to both types of gates. Figure 4-2 lists examples and truth tables for logic actions. When the output of the OR gate is inverted, it is referred to as a NOR gate. Similarly, an inverted AND gate output is a NAND gate.

4-9. In a binary system there are only two states, referred to as H or L. H is the relatively more positive level and L is the relatively less positive level. Positive logic means that the voltage level assigned to the one state is more positive than that assigned to the zero state. Negative logic has the one state less positive than the zero state. Thus, positive logic (logical one) or negative logic (logical zero) must be clearly specified. An H state could be a logical one or a logical zero. However, H must always represent the more positive level. In this manual positive logic is used with the H state (logical one) more positive than the L state (logical zero). A circle at the symbol input shows signal polarity required to activate the function. Figure 4-2 shows four types of symbols that have the same truth tables and can be used interchangeably. The same output function is performed by what appears to be two different logic symbols. The following discussion will show that they are the same. Therefore more than one symbol can be used to represent a particular function.

4-10. De Morgan's Theorem and Logic Symbols

4-11. De Morgan's theorem states: $\overline{A \cdot B} = \overline{A} + \overline{B} = \overline{A} \cdot \overline{B}$, where the dot (·) is read as "and" and the cross (+) is read as "or". The bar across the letters is read as "not". The theorem shows that an AND gate with an inverted output is the same as an OR gate with inverted inputs. The expression $X = \overline{A \cdot B}$ is correct for the AND gate with the inverted output as in Figure 4-2D. From De Morgan's theorem, $X = \overline{A \cdot B} = \overline{A} + \overline{B}$ and the symbol for $\overline{A} + \overline{B}$ is the OR gate with inverted inputs shown in Figure 4-2D. Thus, the same truth table will work for both symbols. Remember that the symbol used must describe the logic function performed. Positive and negative logic differences are shown in Figure 4-1. When positive logic symbology is used to represent negative logic functions, the dual of the function is produced. For example, a positive logic AND gate becomes a negative logic OR gate. Thus, AND is dual of OR and NOR is dual of NAND.

4-12. JK FLIP-FLOP

4-13. The JK flip-flop is a bistable MV with added features. One unique feature is that the JK flip-flop stores two simultaneous inputs at J and K; then changes states when a clock input signal is applied. Three inputs are used for JK operation in addition to the standard two inputs: 1) clock, 2) set, and 3) reset. The clock input is like the normal input for flip-flop operation. When a set input is applied, this sets output Q to a logical one. A reset input sets $\overline{Q}$ to a logical one. In addition to these features, some JK flip-flops have multiple inputs which are internally gated to control the flip-flop output. JK flip-flop action is shown by truth table 4-1. JK flip-flop is shown in Figure 4-3.

Figure 4-3. JK Flip-Flop

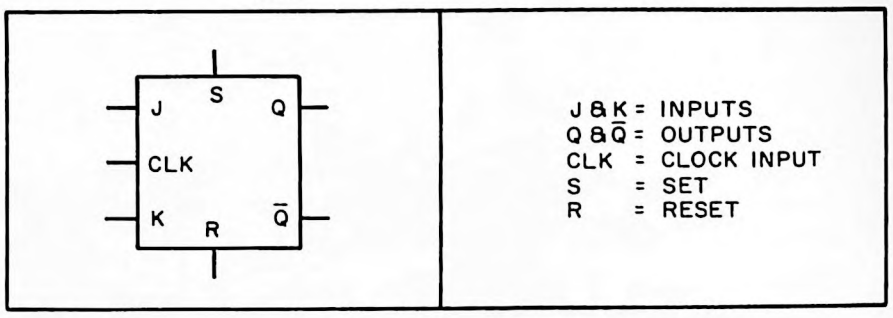


Table 4-1. Truth Table

t_n		$t_n + 1$		t_n = Before clock pulse $t_n + 1$ = After clock pulse
J	K	Q	$\overline{Q}$	
0	0	Q_n	$\overline{Q}_n$	If J = 0 and K = 0, then Q and $\overline{Q}$ will not change from what they were before the clock pulse.
1	0	1	0	If J = 1 and K = 0, then Q will be 1 and $\overline{Q}$ will be 0 after the clock pulse.
0	1	0	1	If J = 0 and K = 1, then Q will be 0 and $\overline{Q}$ will be 1 after a clock pulse.
1	1	$\overline{Q}_n$	Q_n	If J = 1 and K = 1 before the clock pulse, then after the clock pulse Q and $\overline{Q}$ will change states.

4-14. ONE-SHOT MULTIVIBRATOR

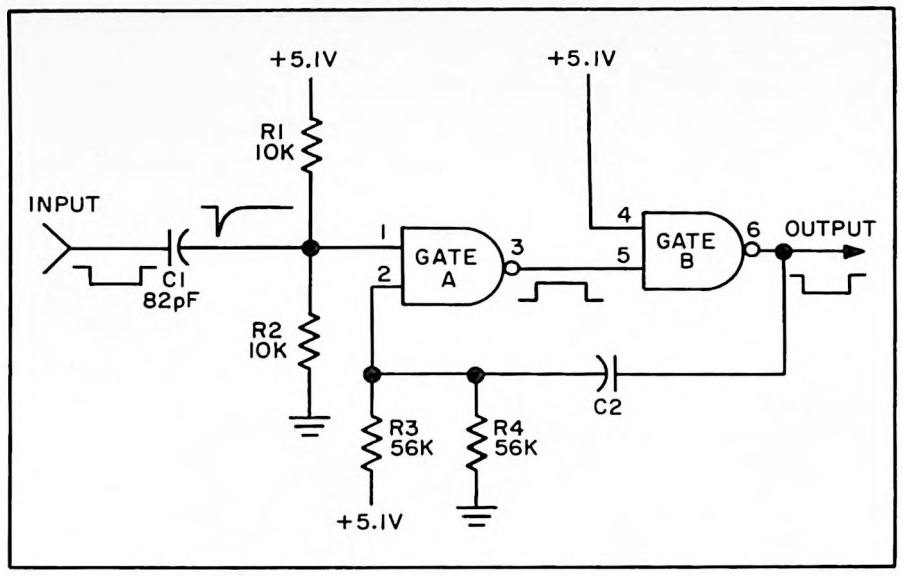
4-15. The reset and transfer one-shot MV's use two NAND gates as shown in Figure 4-4. With no input, pins 1 and 2 of gate A are held high (about 2.5 V) by R1, 2, 3, and 4. Pin 3 of gate A is low. Pin 6 of gate B is high.

4-16. When a negative pulse is applied to the input, pin 1 of gate A goes low for a time determined by C1, R1, and R2. At this time, pin 3 goes high and produces a low output at pin 6 of gate B. This drives pin 2 of gate A low through C2. C2 now charges through R3 and R4. When C2 has charged sufficiently to allow pin 2 of gate A to go high, pin 3 goes low and permits pin 6 of gate B to return to a high. Thus the output is a negative pulse.

4-17. SENSITIVITY CONTROL R1
Schematic Diagram Figure 8-3

4-18. Sensitivity control R1 selects one of two functions: 1) self check or 2) adjustment of input sensitivity. At full counterclockwise, it operates self check

Figure 4-4. One-Shot Multivibrator



switch S3 (see Figure 8-3). In this position, 60 Hz from A2 (P) is connected directly to input amplifier A1. When not in CHECK, it varies the sensitivity from 250 V rms maximum to 0.1 V rms minimum (full clockwise).

4-19. INPUT AMPLIFIER ASSEMBLY A1

Schematic Diagram Figure 8-3

4-20. Input amplifier assembly A1 provides stable voltage gain of the input signal. Diodes CR1 and CR2 are limiters. Field effect transistor Q1 is a source follower to obtain maximum current gain with low noise while maintaining a high input impedance. Q2 is a feedback amplifier for Q1 and improves stability. Q3 and Q4 further amplify the input signal to drive Schmitt trigger Q5 and Q6. The output of Q6 is applied to output amplifier Q7 and Q8. Bias amplifier Q9 with R20 sets the operating point for the Schmitt trigger.

4-21. MAIN BOARD ASSEMBLY A2

Schematic Diagram Figure 8-4

4-22. TIME BASE. The 60 Hz signal from A3(3) is shaped by Q2. The positive portion is applied to IC1c(2). IC1c is the time base NAND gate. When pins 1 and 13 of this gate are high there is a 60 Hz square wave output at pin 12. This signal is applied to IC2(3)(hexade divider). With the GATE SELECTOR switch in the .1 SEC gate position, 10 Hz from the gate output of IC2(6) is applied to the clock input of main gate flip-flop IC4a(6). When GATE SELECTOR switch is in the 1 SEC gate position, the 10 Hz output of IC2(5) is applied to IC3(3) (decade divider). The output of IC3(6) is then applied to the clock input of the main gate flip-flop.

4-23. MAIN GATE. With the GATE SELECTOR switch set to OPEN, CR8 and CR9 are grounded. This disables transfer multivibrator IC5c and IC5a and sample rate multivibrator IC4b. NAND gate IC5d now has a low output at pin 3. This signal is applied to main gate flip-flop IC4a(7) resulting in a low output at pin 10. The output at pin 10 is applied to Q9 base (gate light amplifier) to turn on the gate lamp and also to main gate transistor Q3 to open the main gate. With the main gate open the counted signal at Q1 base is allowed to pass on to the driver and decade counters.

With the GATE SELECTOR switch in CLOSE, the transfer and sample rate multivibrators are disabled by grounding CR10 and CR11. At this time there is a low input applied to IC5d(2) to reverse the main gate flip-flop and close the main gate. With the GATE SELECTOR switch in OPEN, the gate may be closed by grounding the EXT GATE terminal. This provides a low input to IC5(2) through CR16 to close main gate.

4-24. RESET. Reset is done by grounding the inputs of the transfer and reset MV's through CR12 and CR3, respectively. This allows the reset MV to trigger and provide a negative pulse to time base NAND gate IC1c and reset of main gate flip-flop IC4a. At the same time a positive pulse is applied to pin 1 of time base dividers IC2 and IC3 to reset them at 9. This pulse also goes to reset amplifier Q7 and resets the decade counters to zero.

4-25. STORAGE. In storage mode pin 5 of the buffer storage units is held high by IC5a(8). This prevents information in the decade counters from reaching the buffer storage units. When a negative transfer pulse occurs (after the main gate has closed) information in the decade counters passes on to the buffer storage units and the new count is displayed. When STORAGE switch is closed (storage off) the transfer MV is disabled by grounding pin 13 of IC5c. This holds the output at pin 8 of IC5a low and allows a continuous transfer of information from the decade counters to the buffer storage units.

4-26. BLANKING. Blanking occurs when STORAGE switch is on and pin 10 of decade counters IC11, 14 and 17 are grounded. This feature permits blanking of unwanted zeros in the display (zeros left of the most significant digit).

4-27. DECADE COUNTERS. Decade counter IC8 is a high speed, non-blanking decade. Input is on pin 5. It provides a four line coded signal to buffer storage unit IC7. Decade counters IC11, IC14, and IC17 are low frequency blanking decades.

4-28. BUFFER STORAGE UNITS. These units have four inputs and four outputs. When pin 5 is low the buffer storage unit assumes the state of the decade counter and this information is passed to the decoder driver. Pin 5 will be low when there is a transfer pulse or when the STORAGE switch is off.

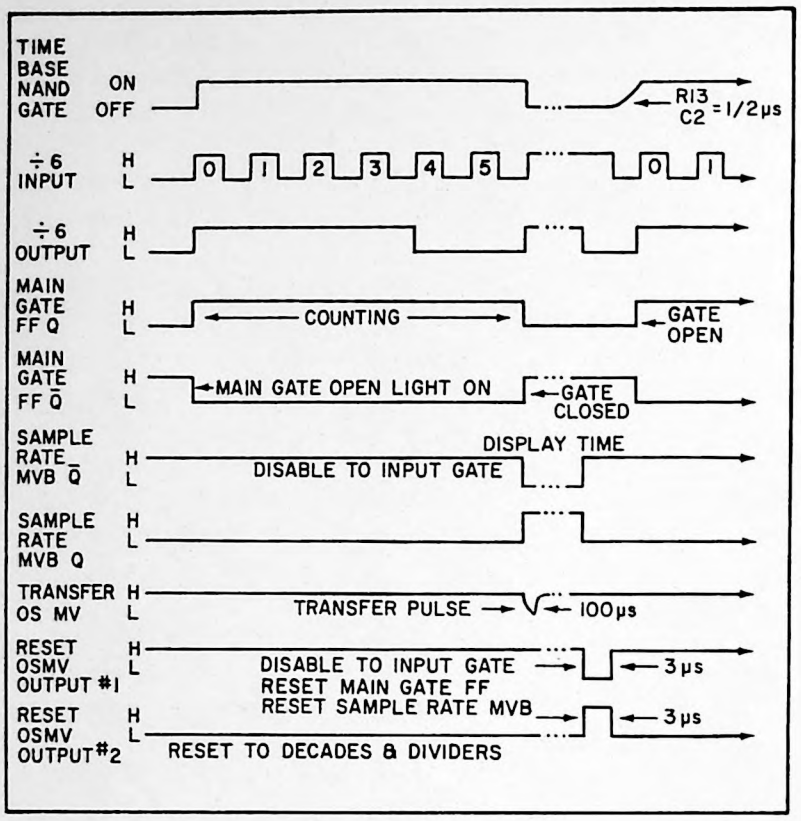
4-29. DECODER DRIVERS. The decoder drivers are four-line to ten-line decoders with 4 inputs and 10 outputs. A low from the decoder driver to a number in the digital display tube will light that number.

4-30. COUNTING SEQUENCE

Refer to Timing Diagram Figure 4-5

4-31. The 60 Hz signal at pin 11 of main board assembly A2 is shaped by Q2. The positive portion at Q2 collector goes to pin 2 of time base NAND gate IC1c. To derive an output from this gate, pins 1 and 13 must be high. When pins 1 and 13 are high, a 60 Hz square wave is applied to pin 3 of IC2 (hexade divider). If the gate control of IC2 pin 7 is grounded (.1 second position of the GATE SELECTOR switch), the gated

Figure 4-5. Timing Diagram



output at pin 6 will become the clock input to main gate flip-flop IC4a. When the GATE SELECTOR is set to 1 sec, the gated output of IC3(6) becomes the clock input to the main gate flip-flop.

4-32. In both .1 sec and 1 sec positions of the GATE SELECTOR switch the set (pin 7) of the main gate flip-flop is held high by IC5d. $\bar{Q}$ at pin 10 of the main gate flip-flop is high. Completion of the first clock pulse will cause Q and $\bar{Q}$ to change states. Now $\bar{Q}$ is low and will open the main gate and light the gate lamp. A low at Q9 base cuts off the transistor. Collector voltage rises and the gate lamp lights. A low at Q3 base cuts off Q3 and the input signal at Q1 base passes on to the driver and decade counters. At this time Q is high and acts as the clock input to sample rate MVB IC4b. This MVB requires a complete change of input state to change its output. Therefore it must wait for the second clock pulse input to the main gate flip-flop before it will change states.

4-33. At the end of the second clock pulse input, Q and $\bar{Q}$ will change states. $\bar{Q}$ will go high and close the main gate and turn off the gate lamp. Q will go low and trigger the sample rate MVB. Q and $\bar{Q}$ of the sample rate MVB will now change states. $\bar{Q}$ goes low and triggers the transfer OSMV to produce a transfer pulse that allows counted information to enter the buffer storage units. The low from $\bar{Q}$ is also applied to pin 13 of the time base NAND gate and prevent any 60 Hz output from pin 12. Sample rate MVB Q output goes high, charging C9 at a rate determined by R21 and R2 (SAMPLE RATE control). When the voltage across C9 is sufficient, Q6 and Q8 will conduct and cause a high input to NAND gate IC5b(4). The subsequent low output from IC5b(6) clears the sample rate MVB and causes Q and $\bar{Q}$ to again change states. $\bar{Q}$ goes high and removes the disabling input from pin 13 of the time base NAND gate. Q goes low and triggers the reset OSMV. The positive reset pulse from IC1b(6) resets IC2 and IC3 to 9 and the decade counters to 0.

4-34. A negative pulse from IC1a(8) is at this time applied to time base NAND gate pin 1 for a period determined by R13 and C2. This allows all reset operations to occur before the next clock pulse enters the time base dividers. This negative pulse is also applied as the set of main gate flip-flop to ensure that it will be ready for the next clock pulse.

4-35. At this time IC2 and IC3 are reset to 9. The main gate flip-flop is preset. The decade counters are reset to 0 and ready for the next count cycle.

4-36. POWER SUPPLY ASSEMBLY A3

Schematic Diagram Figures 8-5 and 8-6

4-37. GENERAL. Power supply assembly A3 provides three regulated voltages: +155, +5.1, and -12 V. These are operating voltages for the instrument.

NOTE

In the following discussion, complete reference designations are used to prevent confusion between parts located on the chassis and parts located on printed circuit board A3.

4-38. PRIMARY POWER. Either 115 Vac or 230 V ac is connected through fuse F1 and power switch S4 (part of SAMPLE RATE control R2). Slide switch S6 on the rear panel connects T1 primary windings in parallel for 115 V ac operation or in series for 230 V ac operation.

4-39. MINUS 12 VOLT SUPPLY. The regulated -12 volt supply consists of full wave bridge rectifier A3CR5 through A3CR8 whose output is filtered by A3C1, regulated by A3Q1 and further filtered by A3C4. Breakdown diode A3CR15 provides a 12.7 V reference for A3Q1. When the output voltage attempts to change, A3Q1 conducts more or less to oppose this change.

4-40. PLUS 5.1 VOLT SUPPLY. The 5.1 volt supply consists of full wave bridge rectifier A3CR9 through A3CR12 whose output is filtered by A3C2 and regulated by series regulator Q1. A3Q4 is the reference amplifier whose gain is adjusted by A3R6. Breakdown diode A3CR17 provides the reference voltage for A3Q4. Thermistor A3RT1 provides temperature compensation for resistive divider A3R6, A3R7, and A3R8. This helps to maintain the gain of the reference amplifier.

4-41. PLUS 155 VOLT SUPPLY. The regulated +155 volt supply consists of full wave bridge rectifier A3CR1 through A3CR4. A3Q2 is the series regulator. Breakdown diodes A3CR13, A3CR14, and A3CR16 provide the reference level for A3Q2. These diodes also contribute to temperature compensation to minimize intensity changes in the readout display tubes. The +155 volt output is adjusted by A3R1. The power supply board used in the Model 5321A has additional components (A3R9, 10, 11, and C6) which provide 90 volts at pin 9. This voltage is not used.

SECTION V

MAINTENANCE

5-1. INTRODUCTION

5-2. This section provides maintenance and service information for the Model 5221A and 5321A Electronic Counters. Included are a table of recommended test equipment, troubleshooting procedures, repair and adjustment procedures, and an in-cabinet performance check which may be used to verify proper operation of the Counter.

5-3. TEST EQUIPMENT

5-4. Recommended test equipment for troubleshooting and performance checking is listed in Table 5-2. Test instruments other than those listed may be used if their specifications equal the required characteristics.

5-5. ASSEMBLY CONNECTION IDENTIFICATION

5-6. Throughout the manual, connections to printed circuit assemblies are referred to in abbreviated form. For example, connection to pin 6 of assembly A1 is A1(6).

5-7. ASSEMBLY DESIGNATIONS

5-8. Table 5-1 lists the designation, name, and part number of printed circuit assemblies used.

Table 5-1. Printed Circuit Assemblies

Assy	Name	HP Part No.
A1	Amplifier-Trigger	05221-6002
A2	Main Board	05221-6001 05221-6005 (Opt. 01) 05221-6006 (Opt. 02)
A3	Power Supply	05221-6003 (5221A) 05221-6010 (5321A)

5-9. IN-CABINET PERFORMANCE CHECK

5-10. GENERAL. The following performance check, Table 5-3 and Test Card, verifies proper operation of all circuits in the Model 5221A and 5321A Electronic Counters and may be used:

a. as part of an incoming inspection check of instrument specifications,

b. periodically, for instruments used in systems where maximum reliability is important,

c. as part of a troubleshooting procedure to locate malfunctioning circuits, and

d. after any repairs or adjustments, before returning instrument to regular service.

Table 5-2. Recommended Test Equipment

Instrument Type	Required Characteristics	HP Part No.
Low Frequency Oscillator	5 Hz to 50 kHz, 0.1 V rms	200CD
High Frequency Oscillator	50 kHz to 10 MHz, 0.1 V rms	651B
Pulse Generator	±50 ns, .3 V, 100 kHz	222A
Oscilloscope Dual Trace Plug-in Horizontal Plug-in	20 MHz Bandwidth 5 mV/cm	140A 1402A 1420A
Divider Probe	10:1, 10 pF, dc to 30 MHz	10001A
Divider Probe	50:1, 2.5 pF, dc to 30 MHz	10002A
50 ohm Feedthrough Termination	Male to Female BNC	10100A
DC VTVM	0 to ±300 V dc, ±1%, 200 megohm impedance	412A
AC VTVM	10 Hz to 10 MHz, ±4%, .001 to 300 V rms	400E
AC Transistor Voltmeter	5 Hz to 10 Hz, ±5%, .001 to 300 V rms	403B
BNC "T" Connector		1250-0781

Table 5-3. In-Cabinet Performance Check

1. MAXIMUM COUNTING RATE: 10 MHz

   a. Set Counter controls as follows:
      SENSITIVITY . . . . . counterclockwise, not in CHECK
      SAMPLE RATE . . . . . slightly clockwise out of POWER OFF
      GATE SELECTOR . . . . . 1 sec

   b. With BNC "T", connect output of Low Frequency Oscillator to Counter INPUT and Oscilloscope input. The Oscilloscope monitors input signal level. Set Oscillator for 0.1 V rms (0.28 V p-p).

   c. Vary frequency of Low Frequency Oscillator from 5 Hz to 50 kHz, keeping output at 0.1 V rms (0.28 V p-p). Adjust Counter SENSITIVITY to trigger on input signal. Counter should properly display frequencies in this range. For frequencies above 9.999 kHz (99.999 kHz Option 01 and 999.999 kHz Option 02) the most significant figure is not displayed.

   d. Substitute HF Oscillator for Low Frequency Oscillator. Vary frequency of HF Oscillator from 50 kHz to 10 MHz keeping output at 0.1 V rms (0.28 V p-p). Adjust Counter SENSITIVITY to trigger on input signal. The Counter should display frequencies in this range.

   e. To measure pulses, the input trigger circuit must be adjusted to compensate for hysteresis effects so that correct triggering occurs with either positive or negative pulses. Refer to paragraph 5-21 for this adjustment.

      NOTE: Shifts in hysteresis limits to obtain a consistent count on positive or negative pulses will affect sine wave sensitivity. Steps d and e above will require an input signal level above .1 V rms if the input circuit is adjusted for pulse operation.

   f. Perform the following check only if trigger circuit has been adjusted for pulse operation. Connect Pulse Generator to Counter INPUT with normal recommended load. Set Pulse Generator for 50 ns, 300 mV pulse, ± depending on the setting of internal trigger control. Set REPETITION RATE of Pulse Generator to 100 kHz. The Counter should display this frequency.

2. INPUT SENSITIVITY: 0.1 V rms sine wave

   NOTE: Internal control allows selection of either positive or negative pulse input.

   Sensitivity is checked by procedure of Item 1, Maximum Counting Rate.

3. GATE CONTROL: Controlled by GATE SELECTOR switch on front panel or by contact closure or saturated NPN transistor ground at EXT GATE jack on rear panel with GATE SELECTOR switch at OPEN.

   a. Set Counter controls as follows:
      GATE SELECTOR . . . . . CLOSE
      SAMPLE RATE . . . . . slightly clockwise out of POWER OFF

   b. Connect Low Frequency Oscillator to Counter INPUT. Set Oscillator to 3 kHz at 0.1 V rms (0.28 V p-p).

   c. Set GATE SELECTOR switch to OPEN; the Counter should be totalizing the input signal. Set the GATE SELECTOR to CLOSE. The Counter should stop counting.

   d. Set GATE SELECTOR to OPEN. Ground the EXT GATE jack on rear panel. Counter should stop counting.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 5221A/5321A
Electronic Counter
Serial No. ____- _____

Tests Performed by _____

Date _____

DESCRIPTION	CHECK
1. MAXIMUM COUNTING RATE: 10 MHz	☐ 5 Hz to 10 MHz minimum
2. INPUT SENSITIVITY: 0.1 V rms sine wave	☐ 0.1 V rms (verified by step 1 above)
3. GATE CONTROL: controlled by front panel GATE SELECTOR switch, or by external contact closure.	☐ OPEN (start counting) ☐ CLOSE (stop count and hold)
With GATE SELECTOR set to OPEN	☐ Contacts open (start counting) ☐ Contacts closed (stop counting)

5-11. VARIABLE LINE VOLTAGE. During the following tests (Table 5-3), Counter should be connected to power source through a variable voltage device so that line voltage may be varied ±10% from nominal (115 or 230 V ac) to assure proper operation of Counter under various supply conditions.

5-12. INSTRUMENT COVER REMOVAL

5-13. To remove top, bottom, or side covers, remove phillips-head screws. Side covers must be removed for access to adjustments.

WARNING

115/230 V AC AND +155 V DC SUPPLY WIRES ARE EXPOSED WHEN EITHER TOP OR BOTTOM INSTRUMENT COVER IS REMOVED. USE EXTREME CAUTION DURING TROUBLESHOOTING, ADJUSTMENT, OR REPAIR. AVOID DAMAGE TO INSTRUMENT BY REMOVING POWER BEFORE REMOVING OR REPLACING COVERS, ASSEMBLIES, OR COMPONENTS.

5-14. ADJUSTMENTS

5-15. Power Supply A3

5-16. To check and adjust power supply voltages, perform the following:

a. Set line voltage to normal value (115 or 230 Vac).

b. Connect dc voltmeter to A3(6).

c. Voltmeter should read between +154 and +156 Vdc. If voltage is outside this range, adjust A3R1 (see Figure 5-1 for 5221A or Figure 5-2 for 5321A).

d. Vary line voltage from 103 to 127 V ac (206 to 254 Vac). The +155 Vdc supply should stay between +145 and +165 Vdc. See Table 5-4.

e. Set line voltage to normal (115 or 230 Vac).

f. Connect dc voltmeter to A3(9).

g. Voltmeter should read between +5.0 and +5.2 Vdc. If voltage is outside this range, adjust A3R6 (see Figure 5-1 for 5221A or Figure 5-2 for 5321A).

h. Vary the line voltage from 103 to 127 Vac (206 to 254 Vac). The +5.1 Vdc supply should stay between +4.95 and 5.25 Vdc.

5-17. Amplifier-Trigger Assembly A1

5-18. Paragraph 5-19 is a procedure to test input amplifier trigger assembly A1 for proper operation. If any test is not passed, see Paragraphs 5-20 and 5-21 for trigger adjustment procedure.

5-19. 5 Hz TO 10 MHz CHECK.

a. Set SENSITIVITY control clockwise.

b. Connect Test Oscillator to Counter INPUT. Set Oscillator output to 5 Hz at 0.1 V rms.

c. Connect Oscilloscope to output at A1(1). Oscilloscope display should be a rectangular wave, about 50% positive and 50% negative.

d. Vary input frequency from 5 Hz to 10 MHz.

e. Oscilloscope display should remain a jitter-free rectangular wave at any frequency between 5 Hz and 10 MHz.

5-20. ADJUSTMENT FOR SINE WAVE OPERATION.

a. Set SENSITIVITY control clockwise.

b. Connect 100 kHz sine wave at 0.1 V rms to Counter INPUT.

c. Turn A1R20 (trigger level adjust; see Figure 5-1 for 5221A or Figure 5-2 for 5321A) fully clockwise.

d. Turn A1R20 counterclockwise until output at A1(1), as observed on oscilloscope, is a stable rectangular waveform, 50% positive and 50% negative (50% duty cycle).

5-21. ADJUSTMENT FOR PULSE OPERATION.

NOTE

Optimum adjustment for pulse operation will differ from optimum sine wave adjustment. Use this adjustment only for pulse operation. Input Schmitt trigger may be adjusted for either positive or negative pulse operation.

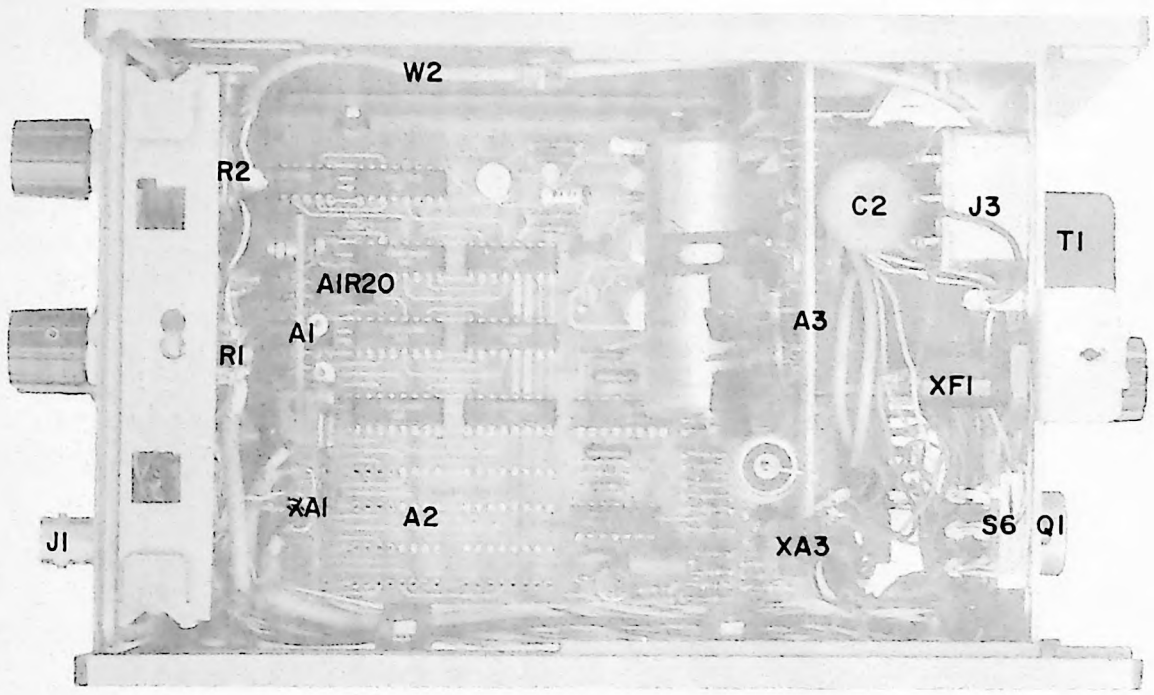
a. Connect Pulse Generator set for 50 ns, 300 mV pulse of desired polarity with repetition rate of 100 kHz. (Connect Generator with normal recommended load.)

b. Connect Oscilloscope to output at A1(1). Adjust A1R20 until a stable pulse is displayed.

Table 5-4. Power Supply Voltage

Test Point	AC Line Voltage (206) 103	AC Line Voltage (230) 115	AC Line Voltage (254) 127	Adjustment	Ripple and Noise
A3(6)	+155 ±10	+155 ±10	+155 ±10	A3R1	Not Filtered
A3(9)	+5.1 ±.15	+5.1 ±.15	+5.1 ±.15	A3R6	.01 V rms max.
A3(4)	-12 ±.5	-12 ±.5	-12 ±.5	None	.003 V rms max.

Figure 5-1. Model 5221A Bottom and Side Internal Views



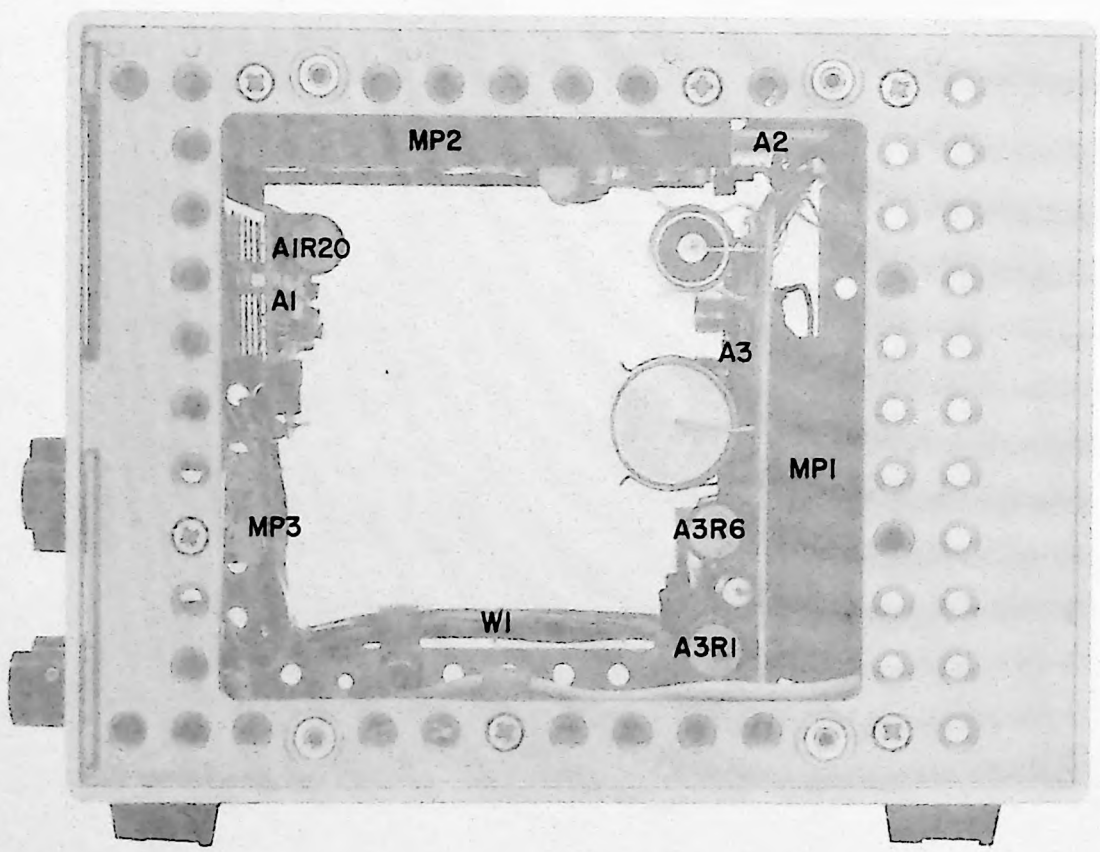
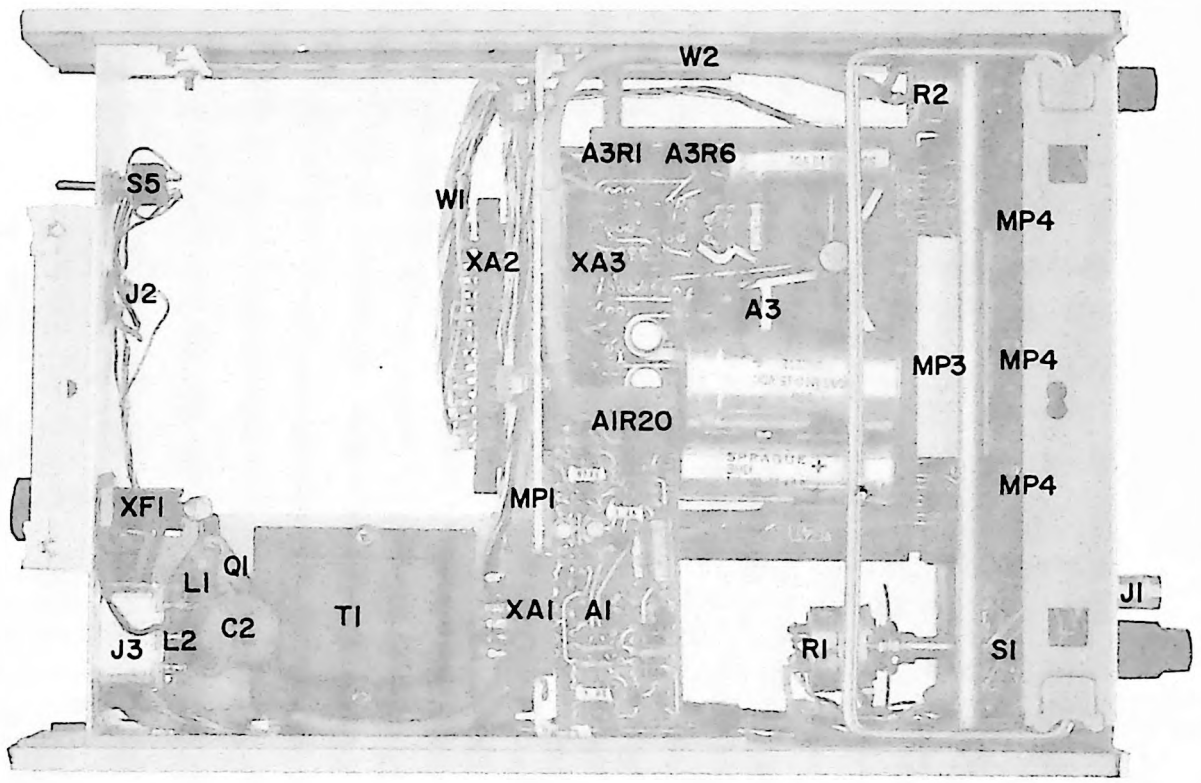
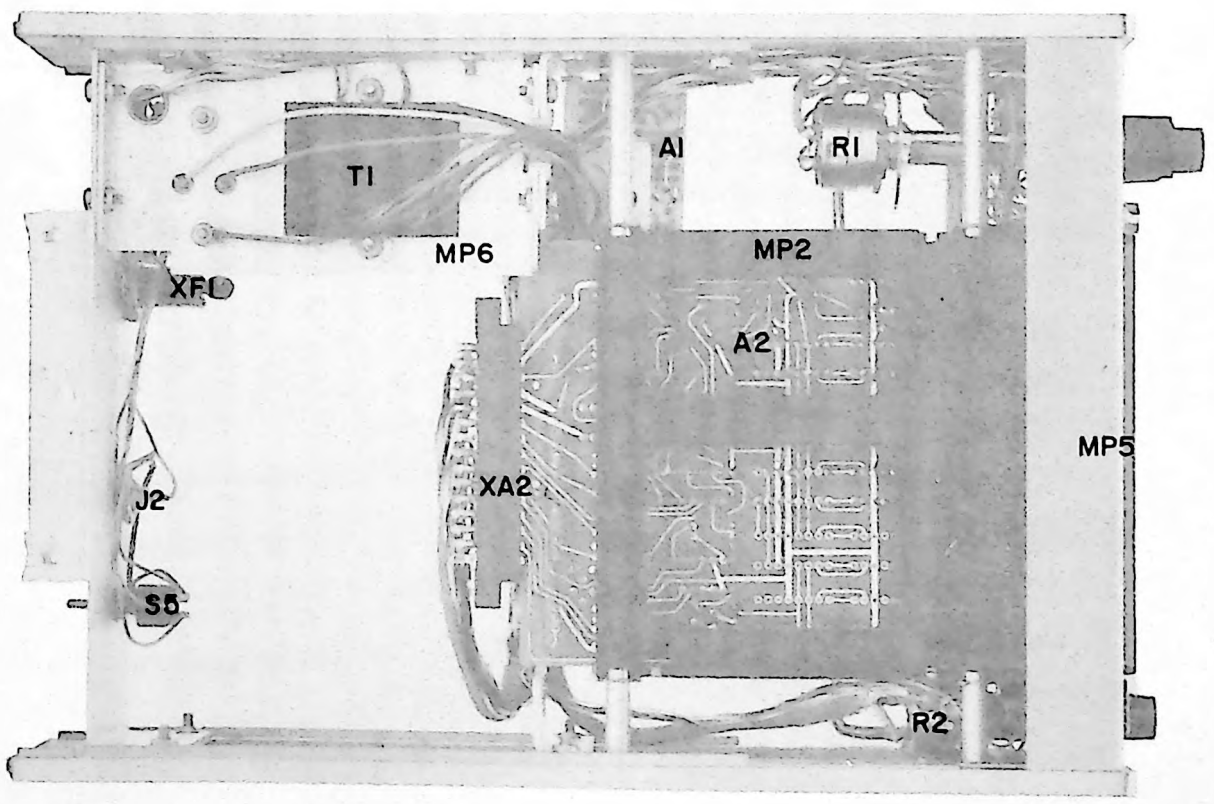


Figure 5-2. Model 5321A Bottom and Top Internal Views





5-22. TROUBLESHOOTING

5-23. General

5-24. Trouble isolation can best be accomplished by first obtaining all possible information from the controls, indicators, and connectors; then logically applying this information to locate the defective circuit or component. Operating procedures in Section III and circuit diagrams in Section VIII can be used to help understand operation. Table 5-1 lists the printed circuit assemblies in the instrument. Figure 5-1 shows the location of assemblies and chassis-mounted components in the 5221A and Figure 5-2 shows the location of assemblies and chassis-mounted components in the 5321A. Refer to component location figures, voltages, waveforms, and schematic diagrams in Section VIII. The performance check (Table 5-3) table is also useful for locating trouble.

5-25. Module Substitution

5-26. Maintenance procedures may be greatly simplified if troubleshooting is done by replacing a bad assembly with a spare assembly known to be operating correctly. When bad assembly is found, trouble then may be traced to the individual components responsible, or the assembly may be shipped to your Hewlett-Packard Sales and Service office for repair.

5-27. Removal of Main Board Assembly A2

5-28. To remove main board assembly A2:

a. Remove the top and both side covers (see Paragraph 5-13).

b. For 5221A, remove front panel window by sliding it out either way.

c. For 5321A, remove front panel window by pushing top of window down at the same time pulling out. When window is released pull up and out.

d. Reach inside the side castings and gently lift sides of main board. Pull the board forward with the fingers.

e. After board is started, remove connector XA2.

f. Push or pull board out of counter being careful to keep board moving in a straight line.

g. To replace board, reverse the above procedure.

Make sure connector XA2 is reconnected and none of the wires are pinched by the board.

5-29. Troubleshooting Assemblies

5-30. Refer to Section IV, Theory of Operation, for information on the operation of circuits. Consult the component location figures, signal waveforms, and voltages which are included with the assembly schematics in Section VIII.

5-31. Printed Circuit Component Replacement

5-32. Component lead-holes in the counter's circuit boards have plated walls to ensure good electrical contact between conductors on the opposite sides of the board. To prevent damage to this plating and to the replacement component, apply heat sparingly, and work carefully. The following replacement procedure is recommended:

a. Remove defective component.

b. Melt solder in component lead-holes. Use clean dry soldering iron to remove excess solder. Clean holes with toothpick or wooden splinter. Do not use metal tool for cleaning as this may damage through-hole plating.

c. Bend leads of replacement component to the correct shape and insert component leads into component lead-holes. Using heat and solder sparingly, solder leads in place. Heat may be applied to either side of board. A heat sink (longnose pliers, commercial heat-sink tweezers, etc) should be used when replacing transistors and diodes in order to prevent excessive heat from being conducted by the leads from the soldering iron to the component.

d. Through-hole plating breaks are indicated by the separation from the board of the round conductor-pad on either side of the board. To repair breaks, press conductor-pads against board and solder replacement component lead to conductor-pad on both sides of board.

5-33. Replacing Integrated Circuits

5-34. If it becomes necessary to replace an integrated circuit, clip the leads as close to the case as possible. With a soldering iron and long nose pliers, carefully remove the wires from each hole. Clean holes as described in Paragraph 5-32 step b.

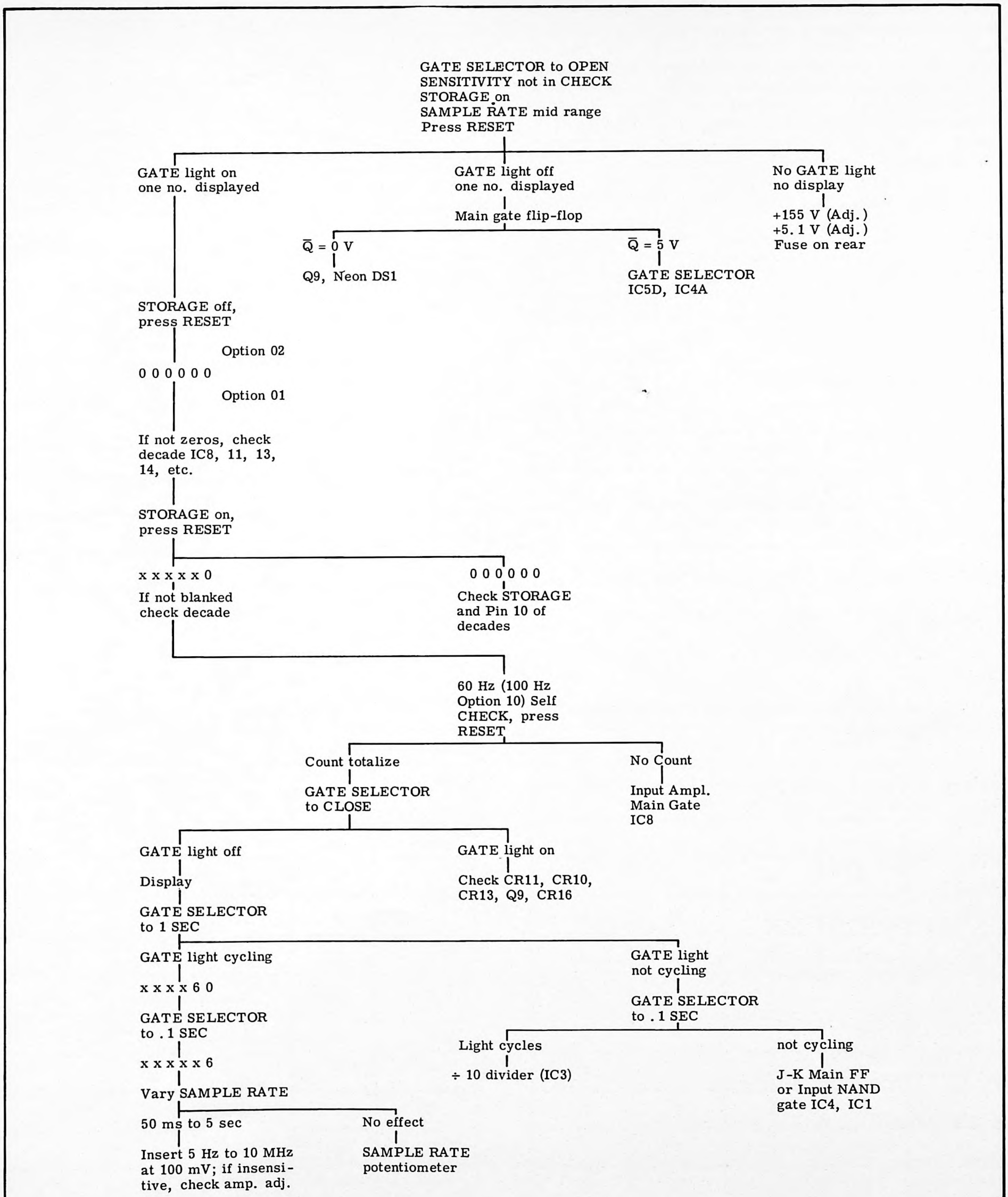
5-35. Troubleshooting Aids

5-36. When trouble is suspected, refer to Section III and perform SELF CHECK procedure. If Counter does not pass SELF CHECK, refer to Table 5-5 for a detailed breakdown of Counter operation in various modes. Once the problem is isolated to a particular area, refer to schematic diagrams in Section VIII.

5-37. Main Gate

5-38. If there is no output from the main gate, check all associated components and voltage levels. If still unable to locate the problem, check the rise time of the input signal from A1 (1) to pin S of the main board. This is typically 20 ns. If the rise time is too slow, the problem is most likely on input amplifier board A1.

Table 5-5. Troubleshooting Chart



5-39. Decade Counters

5-40. With the exception of IC8 (see Table 5-6) all decade counters receive signal input on pin 9 and supply a divide-by-10 output on pin 8. IC8 has its input on pin 5 and divide-by-10 output on pin 1. All decade counters provide -8421 ($\overline{D}\overline{C}\overline{B}A$) BCD output to their associated buffer storage units. Refer to Table 5-7. This output is taken from pins 1, 8, 7, and 6 on IC8 and pins 16, 2, 1, and 15 on the remaining decade counters.

5-41. Buffer Storage Units

5-42. The buffer storage units receive -8421 ($\overline{D}\overline{C}\overline{B}A$) BCD code on pins 9, 7, 8, and 10 from the decade counters when there is a negative transfer pulse at pin 5 or when pin 5 is held low (storage off). -8421 ($\overline{D}\overline{C}\overline{B}\overline{A}$) output is from pins 16, 3, 1, and 14. Refer to Table 5-8.

5-43. Decoder Drivers

5-44. The decoder drivers receive -8421 ($\overline{D}\overline{C}\overline{B}\overline{A}$) BCD code from the buffer storage units on pins 9, 7, 8, and 10. This information is deciphered within the unit and provides an output to one of the 10 digital display tube elements. A low (about 2 V) to an element of the display tube will light that number. Numbers which are not lighted are held high (about 85 V). Refer to Table 5-9.

Table 5-7. Decade Counter Output

Decade Counters IC11, 14, 17 Output H = High (>1.5V), L = Low (<0.4V)				
Digit	Pin Number			
	16	2	1	15
Blank	L	L	L	L
0	H	H	H	H
1	H	H	H	L
2	H	H	L	H
3	H	H	L	L
4	H	L	H	H
5	H	L	H	L
6	H	L	L	H
7	H	L	L	L
8	L	H	H	H
9	L	H	H	L

Table 5-6. High Frequency Decade Output

High Frequency Decade IC8 Output H = High (>1.5V), L = Low (<0.4V)				
Digit	Pin Number			
	1	8	7	6
0	H	H	H	H
1	H	H	H	L
2	H	H	L	H
3	H	H	L	L
4	H	L	H	H
5	H	L	H	L
6	H	L	L	H
7	H	L	L	L
8	L	H	H	H
9	L	H	H	L

Table 5-8. Buffer Storage Output

Buffer Storage Output: H=High (>2.1V); L=Low (<0.4V)				
Digit	Pin Number			
	16	3	1	14
Blank	L	L	L	L
0	H	H	H	H
1	H	H	H	L
2	H	H	L	H
3	H	H	L	L
4	H	L	H	H
5	H	L	H	L
6	H	L	L	H
7	H	L	L	L
8	L	H	H	H
9	L	H	H	L

Table 5-9. Decoder Driver

Decoder Driver (H = High, L = Low)																
Digit	Input L = < 0.4V, H = > 2.1V				10 Line Output H = > 55 V, L = < 3 V										Number Lighted
	Pin Number				Pin Number										
	9	7	8	10	1	2	3	4	11	12	13	14	15	16	
Blank	L	L	L	L	H	H	H	H	H	H	H	H	H	H	None
0	H	H	H	H	L	H	H	H	H	H	H	H	H	H	0
1	H	H	H	L	H	L	H	H	H	H	H	H	H	H	1
2	H	H	L	H	H	H	L	H	H	H	H	H	H	H	2
3	H	H	L	L	H	H	H	L	H	H	H	H	H	H	3
4	H	L	H	H	H	H	H	H	L	H	H	H	H	H	4
5	H	L	H	L	H	H	H	H	H	L	H	H	H	H	5
6	H	L	L	H	H	H	H	H	H	H	L	H	H	H	6
7	H	L	L	L	H	H	H	H	H	H	H	L	H	H	7
8	L	H	H	H	H	H	H	H	H	H	H	H	L	H	8
9	L	H	H	L	H	H	H	H	H	H	H	H	H	L	9

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and HP part number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their HP part number and provides the following information on each part.

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in Table 6-3.

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column).

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Sales and Service office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard part numbers.

6-6. To obtain a part that is not listed; include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

REFERENCE DESIGNATORS

A = assembly	F = fuse	MP = mechanical part	V = vacuum, tube, neon bulb, photocell, etc.
B = motor	FL = filter	P = plug	
BT = battery	IC = integrated circuit	Q = transistor	VR = voltage regulator
C = capacitor	J = jack	R = resistor	W = cable
CP = coupler	K = relay	RT = thermistor	X = socket
CR = diode	L = inductor	S = switch	Y = crystal
DL = delay line	LS = loud speaker	T = transformer	Z = tuned cavity, network
DS = device signaling (lamp)	M = meter	TB = terminal board	
E = misc electronic part	MK = microphone	TP = test point	

ABBREVIATIONS

A = amperes	H = henries	N/O = normally open	RMO = rack mount only
AFC = automatic frequency control	HDW = hardware	NPO = negative positive zero (zero temperature coefficient)	RMS = root-mean square
AMPL = amplifier	HEX = hexagonal		RWV = reverse working voltage
	HG = mercury		
BFO = beat frequency oscillator	HR = hour(s)	NPN = negative-positive-negative	S-B = slow-blow
BE CU = beryllium copper	HZ = hertz		SCR = screw
BH = binder head		NRFR = not recommended for field replacement	SE = selenium
BP = bandpass	IF = intermediate freq		SECT = section(s)
BRS = brass	IMPG = impregnated	NSR = not separately replaceable	SEMICON = semiconductor
BWO = backward wave oscillator	INCD = incandescent		SI = silicon
	INCL = include(s)		SIL = silver
CCW = counter-clockwise	INS = insulation(ed)	OBD = order by description	SL = slide
CER = ceramic	INT = internal	OH = oval head	SPG = spring
CMO = cabinet mount only		OX = oxide	SPL = special
COEF = coefficient	K = kilo = 1000		SST = stainless steel
COM = common		P = peak	SR = split ring
COMP = composition	LH = left hand	PC = printed circuit	STL = steel
COMPL = complete	LIN = linear taper	PF = picofarads = 10^{-12} farads	
CONN = connector	LK WASH = lock washer		TA = tantalum
CP = cadmium plate	LOG = logarithmic taper	PH BRZ = phosphor bronze	TD = time delay
CRT = cathode-ray tube	LPF = low pass filter	PHL = Phillips	TGL = toggle
CW = clockwise		PIV = peak inverse voltage	THD = thread
	M = milli = 10^{-3}	PNP = positive-negative-positive	TI = titanium
DEPC = deposited carbon	MEG = meg = 10^{6}		TOL = tolerance
DR = drive	MET FLM = metal film	P/O = part of	TRIM = trimmer
	MET OX = metallic oxide	POLY = polystyrene	TWT = traveling wave tube
ELECT = electrolytic	MFR = manufacturer	PORC = porcelain	
ENCAP = encapsulated	MHZ = mega hertz	POS = position(s)	U = micro = 10^{-6}
EXT = external	MINAT = miniature	POT = potentiometer	VAR = variable
	MOM = momentary	PP = peak-to-peak	VDCW = dc working volts
F = farads	MTG = mounting	PT = point	
FH = flat head	MY = "mylar"	PWV = peak working voltage	W/ = with
FIL H = fillister head			W = watts
FXD = fixed	N = nano (10^{-9})	RECT = rectifier	WIV = working inverse voltage
	N/C = normally closed	RF = radio frequency	
G = giga (10^{9})	NE = neon	RH = round head or right hand	WW = wirewound
GE = germanium	NI PL = nickel plate		W/O = without
GL = glass			
GRD = ground(ed)			

01194-13

Table 6-1. Reference Designation Index

Reference Designation	Part No.	Description #	Note
A1	05221-6002	ASSY:INPUT AMPLIFIER BOARD	
	05221-2002	BOARD:BLANK PC	
A1C1	0160-2255	C:FXD CER 8.2±0.25PF 500VDCW	
A1C2	0180-0291	C:FXD ELECT 1UF 10% 35VDCW	
A1C3	0180-0229	C:FXD ELECT 33 UF 10% 10VDCW	
A1C4	0180-0137	C:FXD ELECT 100 UF 20% 10VDCW	
A1C5	0160-2250	C:FXD CER 5.1±0.25 PF 500VDCW	
A1C6	0180-0291	C:FXD ELECT 1UF 10% 35VDCW	
A1C7	0160-2257	C:FXD CER 10 PF 5% 500VDCW	
A1CR1	1901-0040	DIODE:SILICON 30MA 30WV	
A1CR2	1901-0040	DIODE:SILICON 30MA 30WV	
A1CR3	1901-0040	DIODE:SILICON 30MA 30WV	
A1Q1	1855-0053	TRANSISTOR:SILICON FET N CHANNEL	
A1Q2	1853-0036	TRANSISTOR:SILICON PNP 2N3906	
A1Q3	1854-0215	TRANSISTOR:SILICON NPN 2N3904	
A1Q4	1853-0036	TRANSISTOR:SILICON PNP 2N3906	
A1Q5	1854-0019	TRANSISTOR:SILICON NPN	
A1Q6	1854-0019	TRANSISTOR:SILICON NPN	
A1Q7	1854-0215	TRANSISTOR:SILICON NPN 2N3904	
A1Q8	1853-0036	TRANSISTOR:SILICON PNP 2N3906	
A1Q9	1853-0036	TRANSISTOR:SILICON PNP 2N3906	
A1R1	0683-5115	R:FXD COMP 510 OHM 5% 1/4W	
A1R2	0684-4711	R:FXD COMP 470 OHM 10% 1/4W	
A1R3	0757-0927	R:FXD MET FLM 1.3K OHM 2% 1/4W	
A1R4	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R5	0757-0934	R:FXD MET FLM 2.7K OHM 2% 1/4W	
A1R6	0757-0944	R:FXD MET FLM 6.8K OHM 2% 1/4W	
A1R7	0683-5615	R:FXD COMP 560 OHM 5% 1/4W	
A1R8	0757-0907	R:FXD MET FLM 200 OHM 2% 1/4W	
A1R9	0757-0925	R:FXD MET FLM 1.1K OHM 2% 1/4W	
A1R10	0757-0939	R:FXD MET FLM 4.3K OHM 2% 1/4W	
A1R11	0757-0934	R:FXD MET FLM 2.7K OHM 2% 1/4W	
A1R12	0757-0917	R:FXD MET FLM 510 OHM 2% 1/4W	
A1R13	0757-0924	R:FXD MET FLM 1.0K OHM 2% 1/4W	
A1R14	0757-0932	R:FXD MET FLM 2.2K OHM 2% 1/4W	
A1R15	0757-0920	R:FXD MET FLM 680 OHM 2% 1/4W	
A1R16	0683-6815	R:FXD COMP 680 OHM 5% 1/4W	
A1R17	0683-2025	R:FXD COMP 2000 OHM 5% 1/4W	
A1R18	0757-0912	R:FXD MET FLM 330 OHM 2% 1/4W	
A1R19	0683-9115	R:FXD COMP 910 OHM 5% 1/4W	
A1R20	2100-1756	R:VAR WW 200 OHM 10% LIN 1/2W	

 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	℗ Part No.	Description #	Note
A1R21	0683-2425	R:FXD COMP 2400 OHM 5% 1/4W	
A2	05221-6001	ASSY:COUNTER BOARD	
	05221-2001	BOARD:BLANK PC	
A2C1	0160-2257	C:FXD CER 10 PF 5% 500VDCW	
A2C2	0140-0149	C:FXD MICA 47 PF 5%	
A2C3	0160-2250	C:FXD CER 5.1±0.25 PF 500VDCW	
A2C4	0160-2257	C:FXD CER 10 PF 5% 500VDCW	
A2C5	0160-0299	C:FXD MY 1800 PF 10% 200VDCW	
A2C6	0150-0093	C:FXD CER 0.01 UF +80-20% 100VDCW	
A2C7	0140-0193	C:FXD MICA 82 PF 5%	
A2C8	0140-0193	C:FXD MICA 82 PF 5%	
A2C9	0180-0229	C:FXD ELECT 33 UF 10% 10VDCW	
A2C10	0170-0040	C:FXD MY .047 UF 10% 200VDCW	
A2C11	0150-0093	C:FXD CER 0.01 UF +80-20% 100VDCW	
A2CR1	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A2CR2	1901-0040	DIODE:SILICON 30MA 30WV	
A2CR3	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR4	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR5	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR6	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR7	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A2CR8	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR9	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR10	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR11	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR12	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR13	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR14	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR15	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR16	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A2CR17	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A2CR18	1902-0197	DIODE BREAKDOWN:SILICON 82.5V 5%	
A2CR19	1902-0197	DIODE BREAKDOWN:SILICON 82.5V 5%	
A2CR20	1901-0025	DIODE:SILICON 100WV 100MA	
A2CR21	1901-0025	DIODE:SILICON 100WV 100MA	
A2CR22	1901-0025	DIODE:SILICON 100WV 100MA	
A2CR23	1901-0025	DIODE:SILICON 100WV 100MA	
A2DS1	1970-0025	DIGITAL DISPLAY TUBE	
A2DS2	1970-0025	DIGITAL DISPLAY TUBE	
A2DS3	1970-0025	DIGITAL DISPLAY TUBE	
A2DS4	1970-0025	DIGITAL DISPLAY TUBE	
A2IC1	1820-0068	INTEGRATED CIRCUIT SN7410N	

 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
A2IC2	1820-0089	INTEGRATED CIRCUIT	
A2IC3	1820-0098	INTEGRATED CIRCUIT	
A2IC4	1820-0076	INTEGRATED CIRCUIT 2N7476N	
A2IC5	1820-0054	INTEGRATED CIRCUIT SN7400N	
A2IC6	1820-0092	INTEGRATED CIRCUIT	
A2IC7	1820-0090	INTEGRATED CIRCUIT	
A2IC8	1820-0079	INTEGRATED CIRCUIT	
A2IC9	1820-0092	INTEGRATED CIRCUIT	
A2IC10	1820-0090	INTEGRATED CIRCUIT	
A2IC11	1820-0093	INTEGRATED CIRCUIT	
A2IC12	1820-0092	INTEGRATED CIRCUIT	
A2IC13	1820-0090	INTEGRATED CIRCUIT	
A2IC14	1820-0093	INTEGRATED CIRCUIT	
A2IC15	1820-0092	INTEGRATED CIRCUIT	
A2IC16	1820-0090	INTEGRATED CIRCUIT	
A2IC17	1820-0093	INTEGRATED CIRCUIT	
A2Q1	1854-0009	TRANSISTOR:SILICON NPN 2N709	
A2Q2	1854-0071	TRANSISTOR:SILICON NPN	
A2Q3	1854-0009	TRANSISTOR:SILICON NPN 2N709	
A2Q4	1854-0009	TRANSISTOR:SILICON NPN 2N709	
A2Q5	1854-0009	TRANSISTOR:SILICON NPN 2N709	
A2Q6	1854-0071	TRANSISTOR:SILICON NPN	
A2Q7	1854-0071	TRANSISTOR:SILICON NPN	
A2Q8	1854-0071	TRANSISTOR:SILICON NPN	
A2Q9	1854-0232	TRANSISTOR:SILICON NPN	
A2R1	0683-8235	R:FXD COMP 82K OHM 5% 1/4W	
A2R2	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A2R3	0683-5135	R:FXD COMP 51K OHM 5% 1/4W	
A2R4	0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	
A2R5	0683-5135	R:FXD COMP 51K OHM 5% 1/4W	
A2R6	0683-5115	R:FXD COMP 510 OHM 5% 1/4W	
A2R7	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A2R8	0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	
A2R9	0683-4325	R:FXD COMP 4300 OHM 5% 1/4W	
A2R10	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A2R11	0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	
A2R12	0683-5115	R:FXD COMP 510 OHM 5% 1/4W	
A2R13	0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	
A2R14	0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	
A2R15	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A2R16	0683-5115	R:FXD COMP 510 OHM 5% 1/4W	
A2R17	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A2R18	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A2R19	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A2R20	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	

 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	℗ Part No.	Description #	Note
A2R21	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A2R22	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A2R23	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A2R24	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A2R25	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A2R26	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A2R27	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A2R28	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A2R29	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A2R30	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	
A2R31	0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	
A2R32	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A2R33	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A2R34	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A2R35	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A2R36	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A2R37	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A3	05221-6003	ASSY:POWER SUPPLY BOARD (5221A ONLY)	
	05221-2003	BOARD:BLANK PC	
	05221-6010	ASSY:POWER SUPPLY BOARD (5321A ONLY)	
	05221-2010	BOARD:BLANK PC	
A3C1	0180-2102	C:FXD ELECT 700 UF +75-10% 25VDCW	
A3C2	0180-2101	C:FXD ELECT 4000 UF +75-10% 15VDCW	
A3C3	0180-1780	C:FXD ELECT 500 UF +75-10% 10VDCW	
A3C4	0180-0032	C:FXD ELECT 10 UF +75-10% 12VDCW	
A3C5	0180-0032	C:FXD ELECT 10 UF +75-10% 12VDCW	
A3C6	0150-0093	C:FXD CER 0.01 UF +80-20% 100VDCW (5321A ONLY)	
A3CR1	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
A3CR2	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
A3CR3	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
A3CR4	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
A3CR5	1901-0049	DIODE:SILICON 50PIV	
A3CR6	1901-0049	DIODE:SILICON 50PIV	
A3CR7	1901-0049	DIODE:SILICON 50PIV	
A3CR8	1901-0049	DIODE:SILICON 50PIV	
A3CR9	1901-0200	DIODE:SILICON 100 PIV 3A	
A3CR10	1901-0200	DIODE:SILICON 100 PIV 3A	
A3CR11	1901-0200	DIODE:SILICON 100 PIV 3A	
A3CR12	1901-0200	DIODE:SILICON 100 PIV 3A	
A3CR13	1902-3036	DIODE BREAKDOWN:SILICON 3.16V	
A3CR14	1902-3036	DIODE BREAKDOWN:SILICON 3.16V	
A3CR15	1902-0031	DIODE BREAKDOWN:12.7V 5%	
A3CR16	1902-3036	DIODE BREAKDOWN:SILICON 3.16V	
A3CR17	1902-3059	DIODE BREAKDOWN:SILICON 3.83V 5%	

 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	℗ Part No.	Description #	Note
A3Q1	1854-0039	TRANSISTOR:SILICON 2N3053	
	1205-0050	HEAT DISSIPATOR	
A3Q2	1854-0232	TRANSISTOR:SILICON NPN	
	1205-0061	HEAT DISSIPATOR	
A3Q3	1854-0071	TRANSISTOR:SILICON NPN	
A3Q4	1854-0071	TRANSISTOR:SILICON NPN	
A3R1	2100-1758	R:VAR WW 1K OHM 10% LIN 1/2W	
A3R2	0686-5135	R:FXD COMP 51K OHM 5% 1/2W	
A3R3	0683-6815	R:FXD COMP 680 OHM 5% 1/4W	
A3R4	0758-0022	R:FXD MET OX 82K OHM 5% 1/2W	
A3R5	0683-1315	R:FXD COMP 130 OHM 5% 1/4W	
A3R6	2100-1756	R:VAR WW 200 OHM 10% LIN 1/2W	
A3R7	0683-3615	R:FXD COMP 360 OHM 5% 1/4W	
A3R8	0683-1315	R:FXD COMP 130 OHM 5% 1/4W	
A3R9	0683-1055	R:FXD COMP 1 MEGOHM 5% 1/4W (5321A ONLY)	
A3R10	0683-1055	R:FXD COMP 1 MEGOHM 5% 1/4W (5321A ONLY)	
A3R11	0683-5145	R:FXD COMP 510K OHM 5% 1/4W (5321A ONLY)	
A3RT1	0839-0021	THERMISTOR:DISC 500 OHM 10%	
		CHASSIS PARTS	
C1	0170-0040	C:FXD MY .047 UF 10% 200VDCW	
C2	0150-0119	C:FXD CER 2 X 0.01 UF 20% 250WVAC	
DS1	2140-0018	LAMP:GLOW NE-2E	
	5040-0234	LAMPHOLDER	
	5040-0235	BASE:LAMPHOLDER	
F1	2110-0017	FUSE:CARTRIDGE 0.15 AMP SLOW BLOW	
	2110-0018	FUSE:CARTRIDGE 0.25 AMP SLOW BLOW	
	1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	
	2190-0037	WASHER:LOCK SST FOR 1/2 THREAD	
	2950-0038	NUT:HEX SST 1/2-24 X 11/16	
	0900-0016	"O" RING:11/16"	
J1	1250-0083	CONNECTOR:BNC	
J2	1250-0083	CONNECTOR:BNC	
J3	1251-0148	CONNECTOR:POWER 3 PIN MALE	
L1	9140-0136	COIL:FXD RF 22 UH	
L2	9140-0136	COIL:FXD RF 22 UH	
MP1	05216-4006	HOLDER:POWER SUPPLY (5221A ONLY)	
MP1	05321-00004	CHASSIS:MAIN (5321A ONLY)	
MP2	05221-4001	CASE:MAIN BOARD(BLACK PLASTIC)	

 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	℗ Part No.	Description #	Note
MP3	05221-0004	SPACER:FRONT PANEL (5221A ONLY)	
MP3	05321-00006	BRACKET:POWER SUPPLY BOARD (5321A ONLY)	
MP4	05221-4002	FRAME:WINDOW (5221A ONLY)	
MP4	05321-00008	SPRING:WINDOW (5321A ONLY)	
MP5	05221-4003	WINDOW (5221A ONLY)	
MP5	05321-40001	WINDOW (5321A ONLY)	
MP6	05321-00001	CHASSIS:POWER SUPPLY (5321A ONLY)	
Q1	1854-0063	TRANSISTOR:NPN SILICON 2N3055	
	1200-0043	INSULATOR:TRANSISTOR MOUNTING	
R1	2100-0273	R:VAR COMP 3 MEGOHM 20% 5 CCWLOG 1/4W (5221A ONLY)	
	0370-0103	KNOB:BLK W/ARROW 5/8 IN. OD 1/4 IN. SHAFT	
	0370-0134	KNOB:ROUND,RED 1/2 DIA (5321A ONLY)	
R2	2100-0318	R:VAR 250K OHM 20% 1/4W/SPST SW (5221A ONLY)	
	2100-2573	R:VAR COMP 250K OHM 20% LIN 1/4W (5321A ONLY)	
	0370-0103	KNOB:BLK W/ARROW 5/8 IN. OD 1/4 IN. SHAFT (5221A ONLY)	
	0370-0102	KNOB:RED BAR (5321A ONLY)	
S1	3100-2072	SWITCH:ROTARY (5221A ONLY)	
	3100-2424	SWITCH:ROTARY (5321A ONLY)	
	0370-0077	KNOB:5/8 SK BAR (5221A ONLY)	
	0370-0099	KNOB:SKIRTED BAR 5/8 DIA (5321A ONLY)	
S2	3101-0052	SWITCH:PUSHBUTTON SPST	
S3		NOT ASSIGNED	
S4		NOT ASSIGNED	
S5	3101-0957	SWITCH:TOGGLE DPDT	
S6	3101-0033	SWITCH:SLIDE DPDT	
T1	9100-2438	TRANSFORMER	
W1	05221-6004	CABLE ASSY:MAIN (5221A ONLY)	
	05321-60010	CABLE ASSY:MAIN (5321A ONLY)	
W2	05221-6007	CABLE ASSY:POWER (5221A ONLY)	

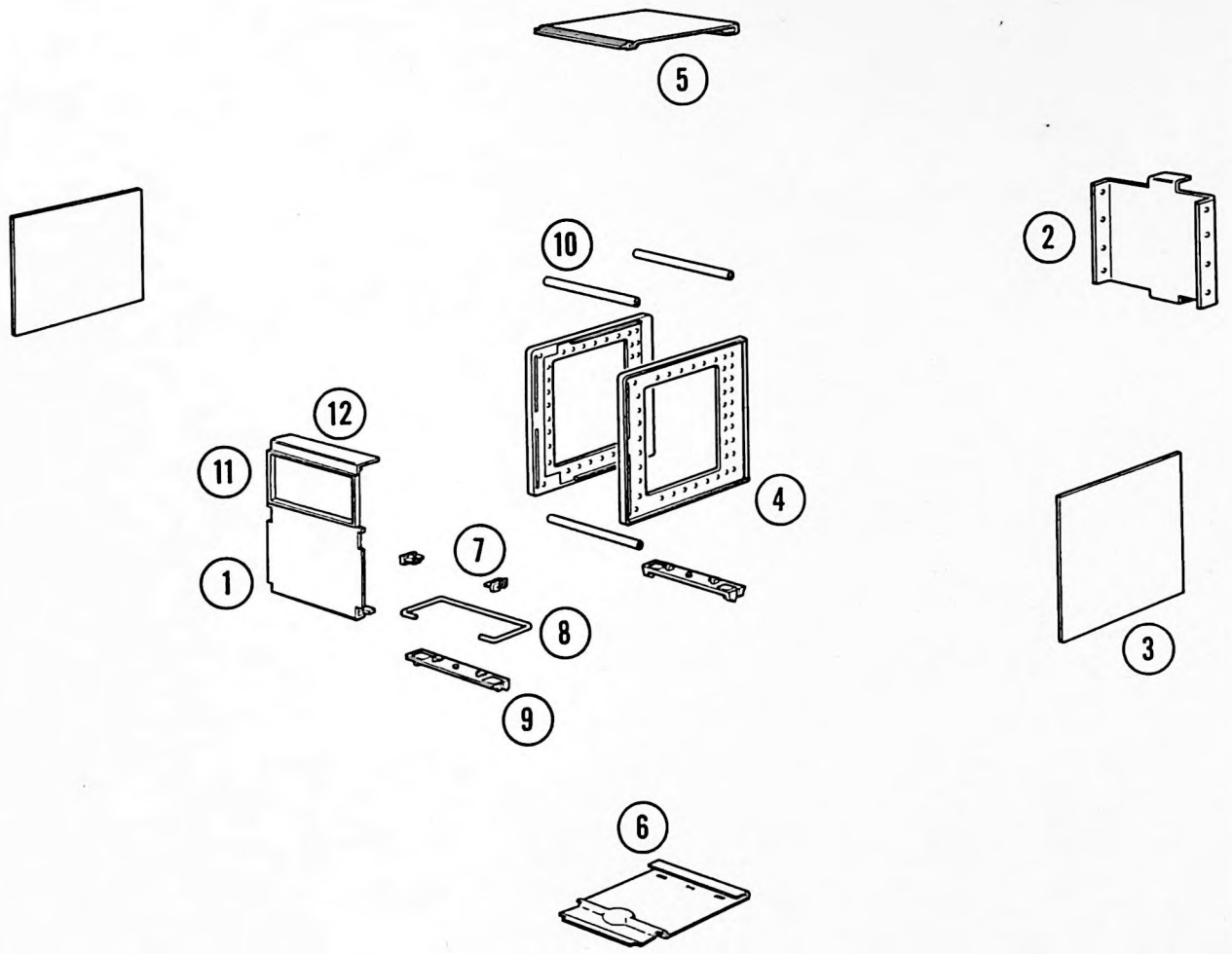
 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
W2	05321-60003	CABLE ASSY:POWER (5321A ONLY)	
W3	8120-0078	CABLE ASSY:POWER CORD	
XA1	1251-0158	CONNECTOR:6-CONTACT	
XA2	1251-0159	CONNECTOR: 30 CONTACT	
XA3	1251-0194	CONNECTOR:PRINTED CIRCUIT 15-CONTACT	
	5000-0230	INSULATOR:P.C. BOARD (5321A ONLY)	

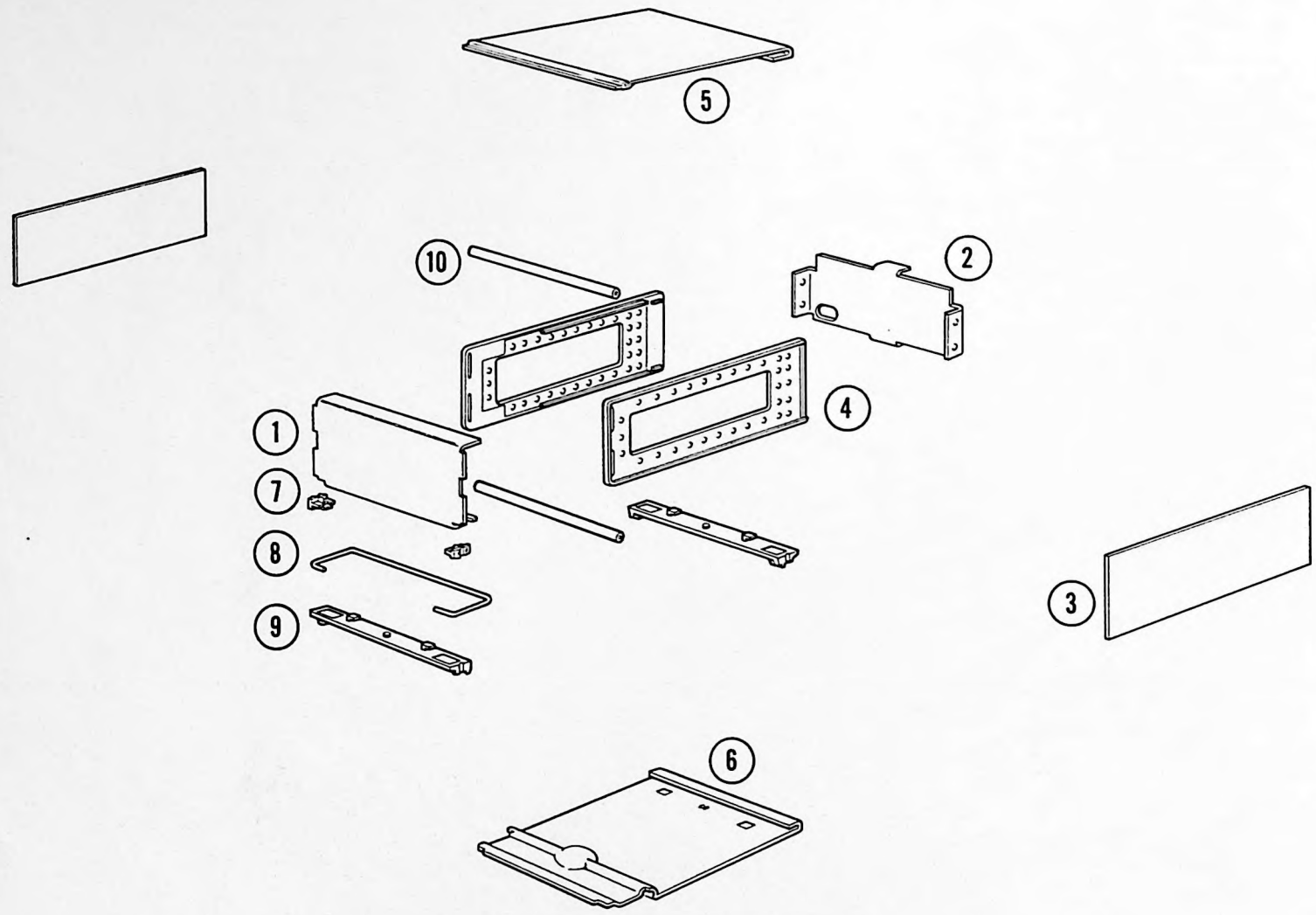
See introduction to this section for ordering information

Figure 6-1. Model 5221A Cabinet Parts



Item	Description	HP Part No.	Quantity
1.	Front Panel	05221-0001	1
2.	Rear Panel	05221-0003	1
3.	Side Cover	5000-0702	2
4.	Side Frame	5060-0702	2
5.	Top Cover	5060-0714	1
6.	Bottom Cover	5000-0713	1
7.	Hinge	5040-0700	2
8.	Tilt Stand	1490-0031	1
9.	Foot Assembly	5060-0727	2
10.	Spacer	5020-0700	3
11.	Window Frame	05221-4002	1
12.	Trim, Top Front	05221-0002	1

Figure 6-2. Model 5321A Cabinet Parts



Item	Description	HP Part No.	Quantity
1.	Front Panel	05321-00003	1
2.	Rear Panel	05321-00009	1
3.	Side Cover	5000-0700	2
4.	Side Frame	5060-0700	2
5.	Top Cover	5060-0724	1
6.	Bottom Cover	5000-0719	1
7.	Hinge	5040-0700	2
8.	Tilt Stand	1490-0031	1
9.	Foot Assembly	5060-0728	2
10.	Spacer	5020-0701	2

Table 6-2. Replaceable Parts

℗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ 5221	TQ 5321
0140-0149	C:FXD MICA 47 PF 5%	28480	0140-0149	1	1
0140-0193	C:FXD MICA 82 PF 5%	28480	0140-0193	2	2
0150-0093	C:FXD CER 0.01 UF +80-20% 100VDCW	91418	TA	2	3
0150-0119	C:FXD CER 2 X 0.01 UF 20% 250WVAC	56289	36C219A	1	1
0160-0299	C:FXD MY 1800 PF 10% 200VDCW	28480	0160-0299	1	1
0160-2250	C:FXD CER 5.1 ±0.25 PF 500VDCW	72982	301-000-COHO-519E	2	2
0160-2255	C:FXD CER 8.2 ±0.25PF 500VDCW	72982	301-NPO-8.2 PF	1	1
0160-2257	C:FXD CER 10 PF 5% 500VDCW	72982	301-000-COHO-100J	3	3
0170-0040	C:FXD MY .047 UF 10% 200VDCW	28480	0170-0040	2	2
0180-0032	C:FXD ELECT 10 UF +75-10% 12VDCW	28480	0180-0032	2	2
0180-0137	C:FXD ELECT 100 UF 20% 10VDCW	28480	0180-0137	1	1
0180-0229	C:FXD ELECT 33 UF 10% 10VDCW	28480	0180-0229	2	2
0180-0291	C:FXD ELECT 1UF 10% 35VDCW	56289	150D105X9035A2	2	2
0180-1780	C:FXD ELECT 500 UF +75-10% 10VDCW	28480	0180-1780	1	1
0180-2101	C:FXD ELECT 4000 UF +75-10% 15VDCW	28480	0180-2101	1	1
0180-2102	C:FXD ELECT 700 UF +75-10% 25VDCW	28480	0180-2102	1	1
0370-0077	KNOB:5/8 SKIRTED BAR	28480	0370-0077	1	
0370-0099	KNOB:SKIRTED BAR 5/8" DIA	28480	0370-0099		1
0370-0102	KNOB:RED BAR	28480	0370-0102		1
0370-0103	KNOB:BLK W/ARROW 5/8 IN. OD 1/4 IN. SHAFT	28480	0370-0103	2	
0370-0134	KNOB:ROUND,RED 1/2 "DIA	28480	0370-0134		1
0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	01121	CB 1025	5	5
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	5	5
0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	01121	CB 1045	2	2
0683-1055	R:FXD COMP 1 MEGOHM 5% 1/4W	01121	CB 1055		2
0683-1315	R:FXD COMP 130 OHM 5% 1/4W	01121	CB 1315	2	2
0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	01121	CB 1525	1	1
0683-2025	R:FXD COMP 2000 OHM 5% 1/4W	01121	CB 2025	1	1
0683-2035	R:FXD COMP 20K OHM 5% 1/4W	01121	CB 2035	6	6
0683-2425	R:FXD COMP 2400 OHM 5% 1/4W	01121	CB 2425	1	1
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	1	1
0683-3615	R:FXD COMP 360 OHM 5% 1/4W	01121	CB 3615	1	1
0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	01121	CB 3925	1	1
0683-4325	R:FXD COMP 4300 OHM 5% 1/4W	01121	CB 4325	1	1
0683-4715	R:FXD COMP 470 OHM 5% 1/4W	01121	CB 4715	1	1
0683-5115	R:FXD COMP 510 OHM 5% 1/4W	01121	CB 5115	4	4
0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	01121	CB 5125	5	5
0683-5135	R:FXD COMP 51K OHM 5% 1/4W	01121	CB 5135	2	2
0683-5145	R:FXD COMP 510K OHM 5% 1/4W	01121	CB 5145		1
0683-5615	R:FXD COMP 560 OHM 5% 1/4W	01121	CB 5615	1	1
0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	01121	CB 5635	4	4
0683-6815	R:FXD COMP 680 OHM 5% 1/4W	01121	CB 6815	2	2
0683-8235	R:FXD COMP 82K OHM 5% 1/4W	01121	EB 8235	1	1
0683-9115	R:FXD COMP 910 OHM 5% 1/4W	01121	CB 9115	1	1
0684-4711	R:FXD COMP 470 OHM 10% 1/4W	01121	CB 4711	1	1
0686-5135	R:FXD COMP 51K OHM 5% 1/2W	01121	EB 5135	1	1
0757-0907	R:FXD MET FLM 200 OHM 2% 1/4W	28480	0757-0907	1	1
0757-0912	R:FXD MET FLM 330 OHM 2% 1/4W	28480	0757-0912	1	1
0757-0917	R:FXD MET FLM 510 OHM 2% 1/4W	28480	0757-0917	1	1
0757-0920	R:FXD MET FLM 680 OHM 2% 1/4W	28480	0757-0920	1	1
0757-0924	R:FXD MET FLM 1.0K OHM 2% 1/4W	28480	0757-0924	1	1
0757-0925	R:FXD MET FLM 1.1K OHM 2% 1/4W	28480	0757-0925	1	1
0757-0927	R:FXD MET FLM 1.3K OHM 2% 1/4W	28480	0757-0927	1	1
0757-0932	R:FXD MET FLM 2.2K OHM 2% 1/4W	28480	0757-0932	1	1

See list of abbreviations in introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ 5221		TQ 5321
0757-0934	R:FXD MET FLM 2.7K OHM 2% 1/4W	28480	0757-0934	2		2
0757-0939	R:FXD MET FLM 4.3K OHM 2% 1/4W	28480	0757-0939	1		1
0757-0944	R:FXD MET FLM 6.8K OHM 2% 1/4W	28480	0757-0944	1		1
0758-0022	R:FXD MET OX 82K OHM 5% 1/2W	28480	0758-0022	1		1
0839-0021	THERMISTOR:DISC 500 OHM 10%	83186	25E11	1		1
0900-0016	"O" RING:11/16"	28480	0900-0016	1		1
1200-0043	INSULATOR:TRANSISTOR MOUNTING	71785	293011	1		1
1205-0050	HEAT DISSIPATOR	28480	1205-0050	1		1
1205-0061	HEAT DISSIPATOR SEMICONDUCTOR	28480	1205-0061	1		1
1250-0083	CONNECTOR:BNC	28480	1250-0083	2		2
1251-0148	CONNECTOR:POWER 3 PIN MALE	87930	1065-1	1		1
1251-0158	CONNECTOR:6-CONTACT	28480	1251-0158	1		1
1251-0159	CONNECTOR: 30 CONTACT	28480	1251-0159	1		1
1251-0194	CONNECTOR:PRINTED CIRCUIT 15-CONTACT	28480	1251-0194	1		
1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	79515	342014	1		1
1820-0054	INTEGRATED CIRCUIT SN7400N	28480	1820-0054	1		1
1820-0068	INTEGRATED CIRCUIT SN7410N	28480	1820-0068	1		1
1820-0076	INTEGRATED CIRCUIT SN7476N	28480	1820-0076	1		1
1820-0079	INTEGRATED CIRCUIT	28480	1820-0079	1		1
1820-0089	INTEGRATED CIRCUIT	28480	1820-0089	1		1
1820-0090	INTEGRATED CIRCUIT	28480	1820-0090	4		4
1820-0092	INTEGRATED CIRCUIT	28480	1820-0092	4		4
1820-0093	INTEGRATED CIRCUIT	28480	1820-0093	3		3
1820-0098	INTEGRATED CIRCUIT	28480	1820-0098	1		1
1853-0036	TRANSISTOR:SILICON PNP 2N3906	28480	1853-0036	4		4
1854-0009	TRANSISTOR:SILICON NPN 2N709	07263	2N709	4		4
1854-0019	TRANSISTOR:SILICON NPN	28480	1854-0019	2		2
1854-0039	TRANSISTOR:SILICON 2N3053	02735	2N3053	1		1
1854-0063	TRANSISTOR:NPN SILICON 2N3055	02735	2N3055	1		1
1854-0071	TRANSISTOR:SILICON NPN	28480	1854-0071	6		6
1854-0215	TRANSISTOR:SILICON NPN 2N3904	28480	1854-0215	2		2
1854-0232	TRANSISTOR:SILICON NPN	28480	1854-0232	2		2
1855-0053	TRANSISTOR:SILICON FET N CHANNEL	28480	1855-0053	1		1
1901-0025	DIODE:SILICON 100WV 100MA	28480	1901-0025	4		4
1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	28480	1901-0028	4		4
1901-0040	DIODE:SILICON 30MA 30WV	28480	1901-0040	4		4
1901-0049	DIODE:SILICON 50PIV	28480	1901-0049	4		4
1901-0081	DIODE:SILICON 50 VOLTS WORKING	28480	1901-0081	3		3
1901-0200	DIODE:SILICON 100 PIV 3A	02735	1N4998	4		4
1902-0031	DIODE BREAKDOWN:12.7V 5%	28480	1902-0031	1		1
1902-0197	DIODE BREAKDOWN:SILICON 82.5V 5%	28480	1902-0197	2		2
1902-3036	DIODE BREAKDOWN:SILICON 3.16V	28480	1902-3036	3		3
1902-3059	DIODE BREAKDOWN:SILICON 3.83V 5%	28480	1902-3059	1		1
1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	28480	1910-0016	13		13
1970-0025	DIGITAL DISPLAY TUBE	28480	1970-0025	4		4
2100-0273	R:VAR COMP 3 MEGOHM 20% 5 CCWLOG 1/4W	28480	2100-0273	1		
2100-0318	R:VAR 250K OHM 20% 1/4W/SPST SW	28480	2100-0318	1		
2100-1756	R:VAR WW 200 OHM 10% LIN 1/2W	28480	2100-1756	2		2
2100-1758	R:VAR WW 1K OHM 10% LIN 1/2W	28480	2100-1758	1		1
2100-2573	R:VAR COMP 250K OHM 20% LIN 1/4W	28480	2100-2573			1
2110-0017	FUSE:CARTRIDGE 0.15 AMP SLOW BLOW	75915	313.150	1		1
2110-0018	FUSE:CARTRIDGE 0.25 AMP SLOW BLOW	75915	313.250	1		1
2140-0018	LAMP:GLOW NE-2E	24455	NE 2E1	1		1
2190-0037	WASHER:LOCK SST FOR 1/2 THREAD	78189	1224-08	1		1

See list of abbreviations in introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ 5221	TQ 5321
2950-0038	NUT:HEX SST 1/2-24 X 11/16	75915	903-12	1	1
3100-2072	SWITCH:ROTARY	28480	3100-2072	1	
3100-2424	SWITCH:ROTARY	28480	3100-2424		1
3101-0033	SWITCH:SLIDE DPDT	79727	6510 C	1	1
3101-0052	SWITCH:PUSHBUTTON SPST	82389	961 LESS HWD	1	1
3101-0957	SWITCH:TOGGLE DPDT	28480	3101-0957	1	1
5000-0230	INSULATOR:P.C. BOARD	28480	5000-0230		1
5040-0234	LAMPHOLDER	28480	5040-0234	2	2
8120-0078	CABLE ASSY:POWER CORD	28480	8120-0078	1	1
9100-2438	TRANSFORMER	28480	9100-2438	1	1
9140-0136	COIL:FXD RF 22 UH	28480	9140-0136	2	2
05216-4006	HOLDER:POWER SUPPLY	28480	05216-4006	1	
05221-0004	SPACER:FRONT PANEL	28480	05221-0004	1	
05221-2001	BOARD:BLANK PC	28480	05221-2001	1	1
05221-2002	BOARD:BLANK PC	28480	05221-2002	1	1
05221-2003	BOARD:BLANK PC	28480	05221-2003	1	
05221-2010	BOARD:BLANK PC	28480	05221-2010		1
05221-4001	CASE:MAIN BOARD(BLACK PLASTIC)	28480	05221-4001	1	1
05221-4002	FRAME:WINDOW	28480	05221-4002	1	
05221-4003	WINDOW	28480	05221-4003	1	
05221-6001	ASSY:COUNTER BOARD	28480	05221-6001	1	1
05221-6002	ASSY:INPUT AMPLIFIER BOARD	28480	05221-6002	1	1
05221-6003	ASSY:POWER SUPPLY BOARD	28480	05221-6003	1	
05221-6004	CABLE ASSY:MAIN	28480	05221-6004	1	
05221-6007	CABLE ASSY:POWER	28480	05221-6007	1	
05221-6010	ASSY:POWER SUPPLY BOARD	28480	05221-6010		1
05321-00001	CHASSIS:POWER SUPPLY	28480	05321-00001		1
05321-00004	CHASSIS:MAIN	28480	05321-00004		1
05321-00006	BRACKET:POWER SUPPLY BOARD	28480	05321-00006		1
05321-00008	SPRING:WINDOW	28480	05321-00008		1
05321-40001	WINDOW	28480	05321-40001		1
05321-60003	CABLE ASSY:POWER	28480	05321-60003		1
05321-60010	CABLE ASSY:MAIN	28480	05321-60010		1

See list of abbreviations in introduction to this section

Table 6-3. Manufacturers Code List

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc.	Cherry Hill, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02116	Wheelock Signals, Inc.	Long Branch, N.J.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Sumerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Arco Electronic Inc.	Great Neck, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Wheeling, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc	San Mateo, Calif.
05397	Union Carbide Corp., Linde Div., Kemet Dept.	Cleveland, Ohio
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Semcor Div. Components Inc.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp., The	Monterey Park, Calif.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Calif.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11314	National Seal	Downey, Calif.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc. Data System Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12728	Elmar Filter Corp.	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	San Gabriel, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15287	Scionics Corp.	Northridge, Calif.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15631	Cabletronics	Costa Mesa, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Amelco Inc.	Mt. View, Calif.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N.J.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokoma, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
17870	McGraw-Edison Co.	Manchester, N.H.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
18324	Signetics Corp.	Sunnyvale, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19589	Concoa	Baldwin Park, Calif.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas

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From: FSC. Handbook Supplements
H4-1 Dated AUGUST 1966
H4-2 Dated NOV. 1962

Table 6-3. Manufacturers Code List Cont'd.

Code No.	Manufacturer	Address
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema, Div. Aerovox Corp.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap. Div.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Elect Co.	Hicksville, L.I., N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
73957	Groov-Pin Corp.	Ridgefield, N.J.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Label Co.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	. . . . .
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Electronics, Inc.	Cambridge, Maryland
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp. Space & Defense System Div.	Paramus, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N,J,
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.

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From: FSC. Handbook Supplements
H4-1 Dated AUGUST 1966
H4-2 Dated NOV. 1962

Table 6-3. Manufacturers Code List Cont'd.

Code No.	Manufacturer	Address
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Eng. Corp:	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisade's Park, N.J.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co. Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp. Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N.J.
87034	Marco Industries	Anaheim, Calif.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89473	G.E. Distributing Corp.	Schenectady, N.Y.
89665	United Transformer Co.	Chicago, Ill.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91146	ITT Cannon Elect, Inc., Salem Div.	Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91886	Malco Mfg. Co., Inc.	Chicago, Ill.
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N.Y.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Wesbury Long Island, N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Palisades Park, N.J.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.,	Dania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zero Mfg. Co.	Burbank, Calif.
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Div. of Hewlett-Packard Co.	Palo Alto, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind., Capacitor Div.	Monrovia, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CS	Hewlett-Packard Co., Colorado Springs	Colorado Springs, Colorado
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.

00015-44
Revised: September, 1967

From: FSC. Handbook Supplements
H4-1 Dated AUGUST 1966
H4-2 Dated NOV 1962

SECTION VII

OPTIONS AND MANUAL CHANGES

7-1. OPTIONS

7-2. The counters have three options available. They are: Option 01, 5 digit readout; Option 02, 6 digit readout; and Option 10 which permits operation from 50 Hz power line frequency. Options available are listed in Table 7-1.

7-3. OPTION 01. Option 01 consists of the following additional components on main board A2 (Figure 8-3): IC18, 19, 20, DS5, CR24, and R38.

7-4. OPTION 02. Option 02 includes components for Option 01 plus the following (Figure 8-3): IC21, 22, 23, DS6, CR25, and R39.

7-5. DIGIT DISPLAY KIT. The parts required for Options 01 and 02 may be ordered as a kit. Two kits are required for Option 02. Parts for the display kit are listed in Table 7-2.

7-6. OPTION 10. Option 10 main board is similar to the standard main board except for three components as shown in Figure 7-2. C12 provides 100 Hz from the +155 V supply (which is not filtered) to shaping amplifier Q2. R1 is a higher value to give necessary attenuation for the self check signal. IC2 is a divide-by-10 divider. The HP part numbers for C12, R1, and IC2 are listed below. See Figure 7-1 for component location.

Part	Description	HP Part No.
C12	.0047 μF	0170-0021
R1	150K ohm	0683-1545
IC2	Decade Divider	1820-0098

7-7. MANUAL CHANGES

7-8. Current Instruments

7-9. This manual applies directly to 5221A counters with serial prefix 740 and to 5321A counters with serial prefix 808 (refer to paragraph 1-11).

7-10. Newer Instruments

7-11. As changes are made, newer instruments may have serial numbers not listed in this manual. The manuals for these instruments will be supplied with an additional "Manual Changes" sheet containing the required information; contact the nearest Hewlett-Packard Sales and Service office for information if this sheet is missing.

7-12. Older Instruments

7-13. This manual with changes listed in Table 7-3 also applies to 5221A counters having serial prefix number 716. All 5321A instruments to date are also covered in this manual with no manual changes required.

Table 7-1. Options

Option	Description	HP Part No.
01	5 digit readout	05221-6005
02	6 digit readout	05221-6006
10	50 Hz operation	05221-6021
10 + 1	50 Hz with 5 digit readout	05221-6023
10 + 2	50 Hz with 6 digit readout	05221-6024

Table 7-2. Digital Display Kit

Description	HP Part No.	Req. No.
KIT, DIGIT DISPLAY	05221-6022	
Resistor, fxd, 20K ohm	0683-2035	1
Connector, Single Contact	1251-1556	11
Integrated Circuit	1820-0090	1
Integrated Circuit	1820-0092	1
Integrated Circuit	1820-0093	1
Diode	1901-0025	1
Tube, electron	1970-0025	1

Table 7-3. Manual Changes

Instrument Serial Prefix No.	Manual Changes
716	1, 2 (5221A only)

CHANGE 1: (5221A only)

Delete green wire from S1AF(7-1/2) to wiper of SAMPLE RATE control R2. See Figure 8-3.

CHANGE 2: (5221A only)

Figure 8-3, A2 Main Board Assembly,
A2R21: Change to 470 ohm

Table 6-1
A2R21: Change to R: fxd, comp, 470 ohm, 5%, 1/4W; HP Part No. 0683-4715.

Figure 7-1. Main Board A2 (Option 10)

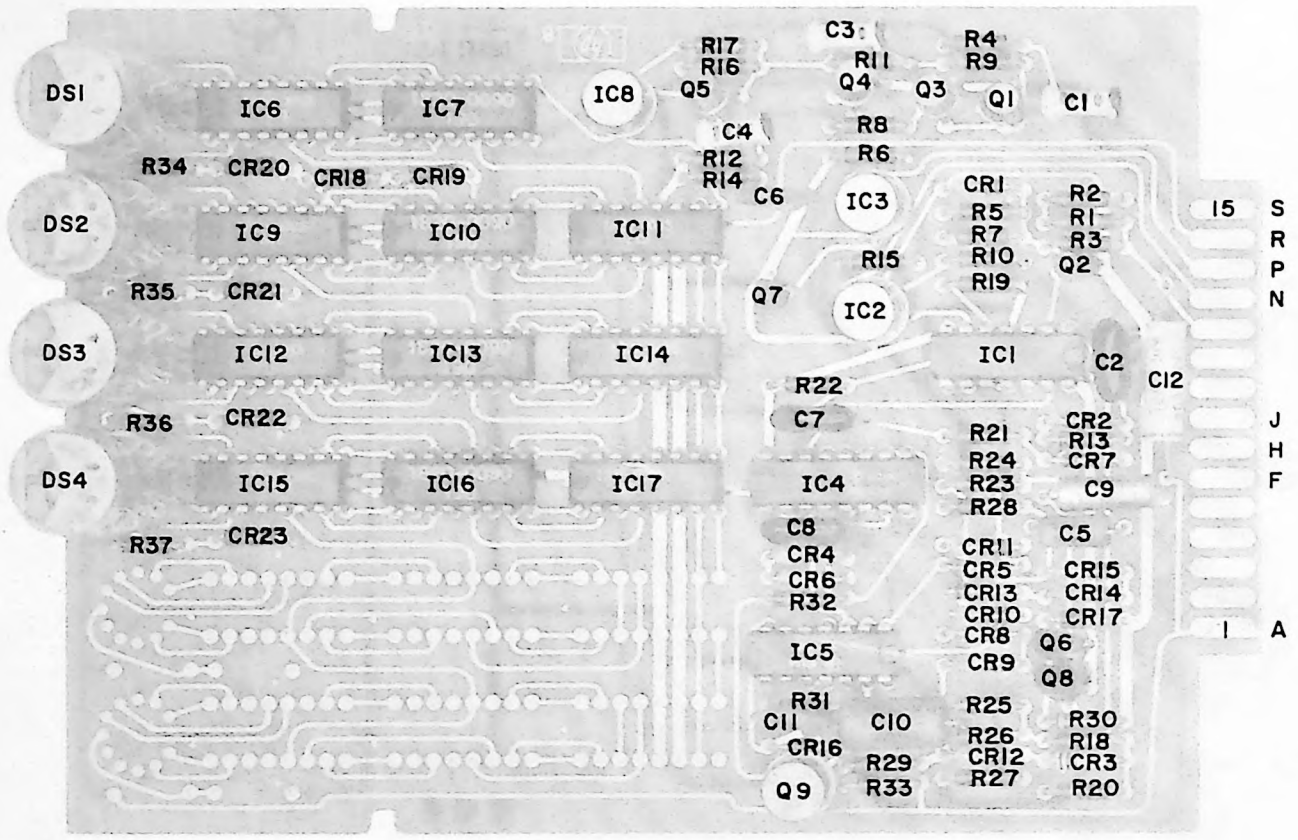
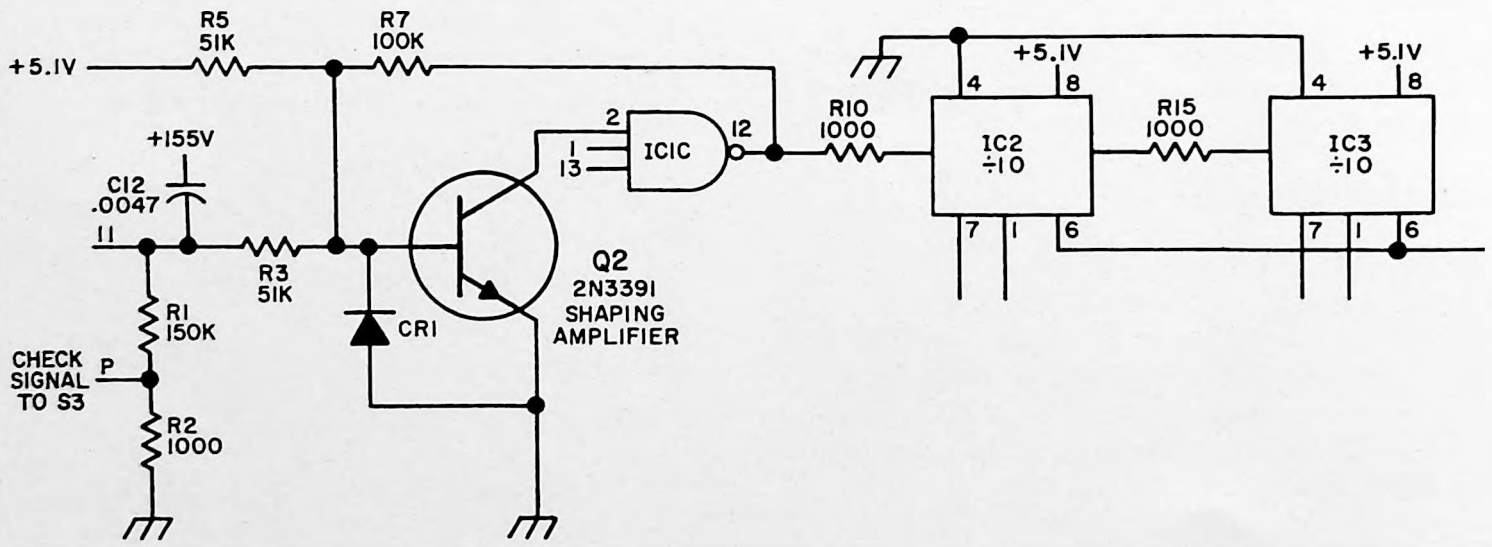


Figure 7-2. Partial Schematic of A2 Time Base (Option 10)



SECTION VIII

CIRCUIT DIAGRAMS

8-1. This section includes the following:

a. General notes for schematic diagrams in Figure 8-1.

b. Schematic diagrams and component location illustrations of counter circuit board assemblies in the order of their assembly designation (A1 through A3, Figures 8-2 through 8-6). These figures may also include waveforms and voltages. Top and bottom views of integrated circuits are shown with pin numbers for identification.

8-2. The diagrams, when unfolded, can be used with other parts of the manual or when the manual is closed.

8-3. Dc voltages are measured with HP Model 412A DC Voltmeter. Typical voltages are shown.

8-4. Waveforms taken with HP Model 140A Oscilloscope with the HP 1402A and 1420A Vertical and Horizontal plug-ins. Oscilloscope vertical amplifier bandwidth is 20 MHz and is used with 10:1 divider probe HP 10001A.

8-5. Shaded areas on the schematic diagrams indicate printed circuit assemblies. All components within the shaded areas are mounted on the boards.

Figure 8-1. Schematic Diagram Notes

SYMBOLS

FRONT PANEL

REAR PANEL

KNOB CONTROL

SCREWDRIVER ADJUST

CW — WIPER MOVES TOWARD "CW" WHEN CONTROL IS ROTATED CLOCKWISE

POWER LINE GROUND

CIRCUIT COMMON GROUND

8 — TEST POINT

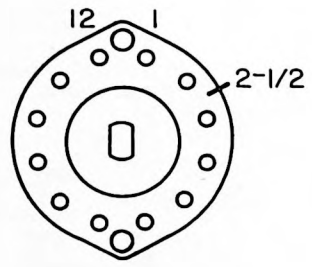
"AND" GATE

NAND GATE

WAVEFORMS SHOWN ARE TYPICAL

SWITCH DESIGNATIONS

A3S1BR(2-1/2)

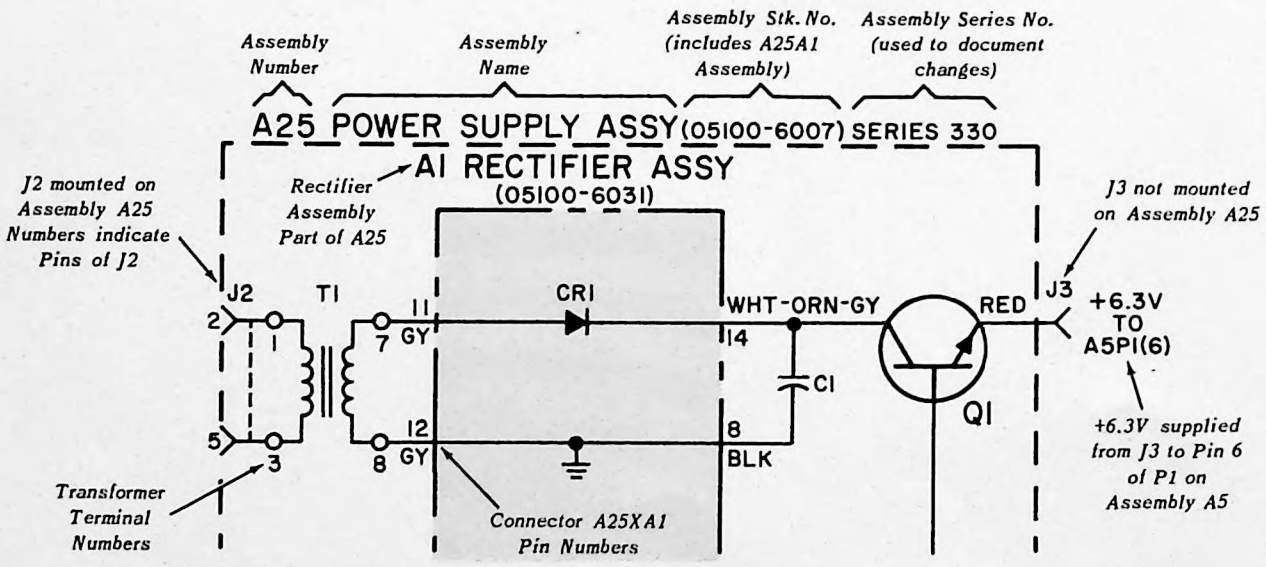


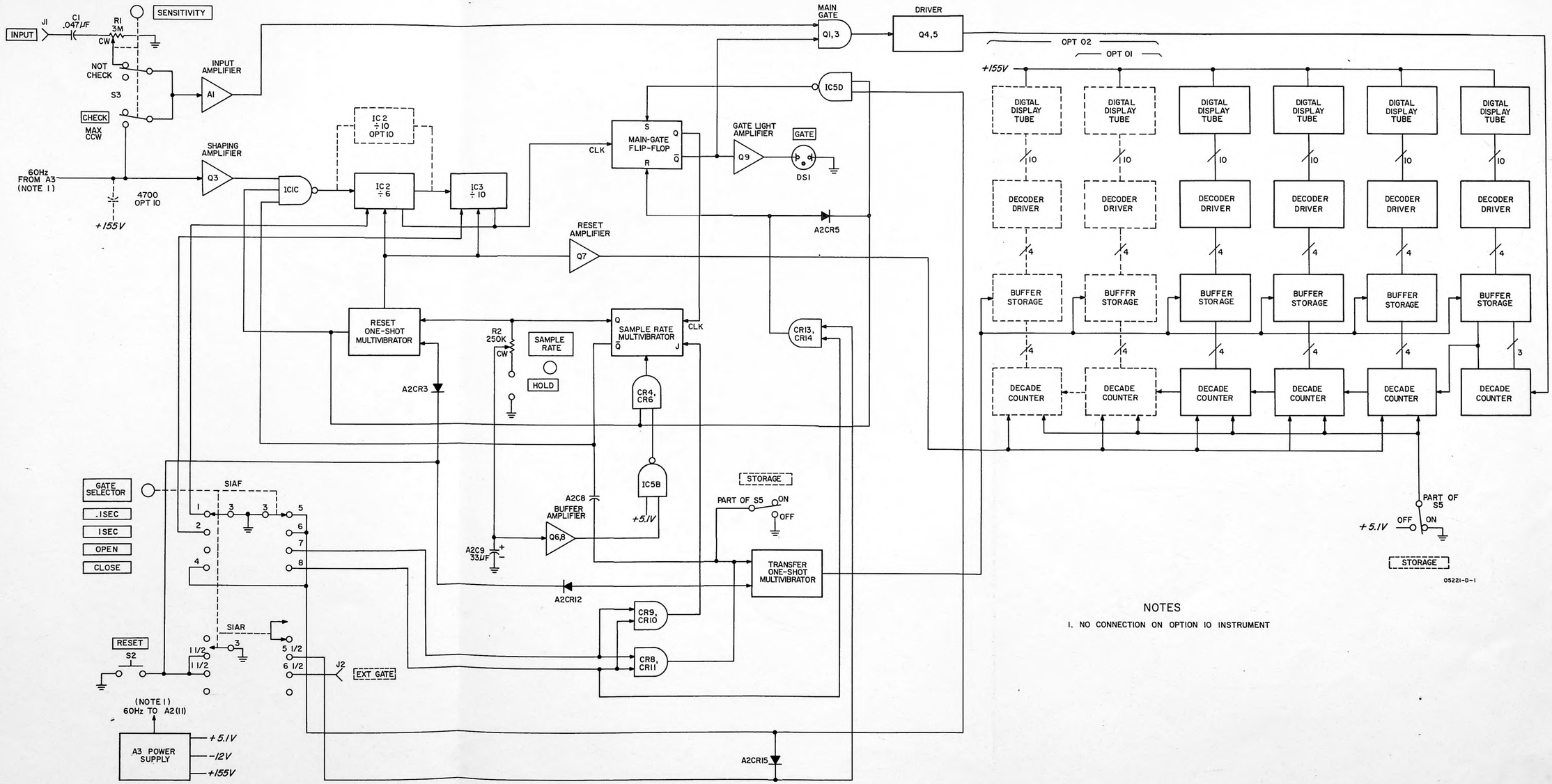
A3S1	SWITCH S1 WITHIN ASSEMBLY A3
B	2ND WAFER FROM FRONT (A=1ST, ETC)
R	REAR OF WAFER (F=FRONT)
(2-1/2)	TERMINAL LOCATION ($2\frac{1}{2}$) (VIEWED FROM FRONT)

REFERENCE DESIGNATIONS

REFERENCE DESIGNATIONS WITHIN ASSEMBLIES ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.

ASSEMBLY	ABBREVIATION	COMPLETE DESCRIPTION
A25	C1	A25C1
A25A1	CR1	A25A1CR1
NO PREFIX	J3	J3

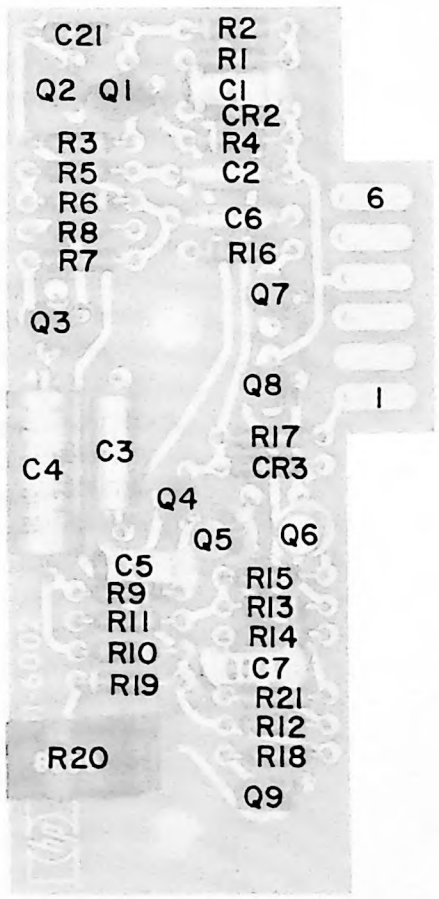


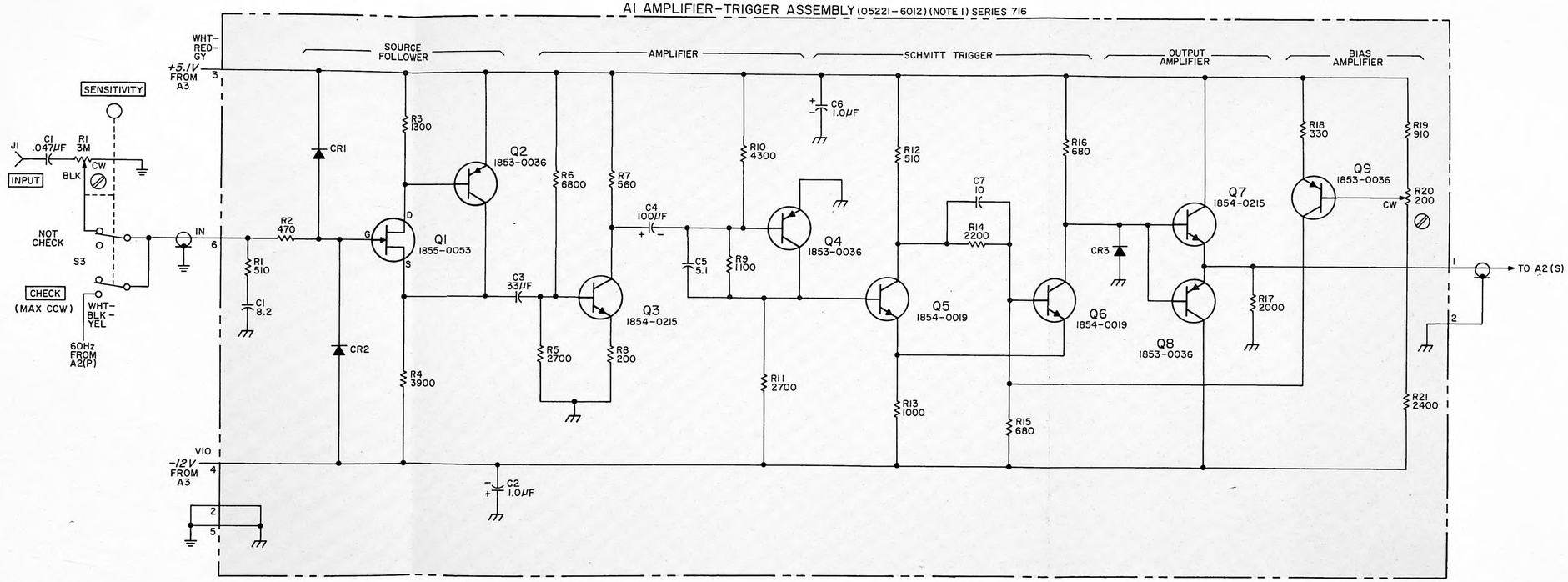


NOTES

1. NO CONNECTION ON OPTION 10 INSTRUMENT

Figure 8-2. Block Diagram


C21
R2
R1
Q2 Q1
C1
CR2
R3
R4
R5
C2
R6
6
C6
R8
R7
R16
Q7
Q3
Q8
1
R17
C3
C4
CR3
Q4
Q5
Q6
C5
R15
R9
R13
R11
R14
R10
C7
R19
R21
R12
R20
R18
Q9



NOTES

1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN PICOFARADS;

REFERENCE DESIGNATIONS

NO PREFIX	A1
C1	C1-7
	CR1-3
J1	
R1	Q1-9
	R1-21

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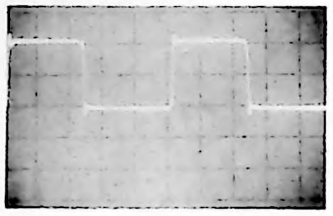
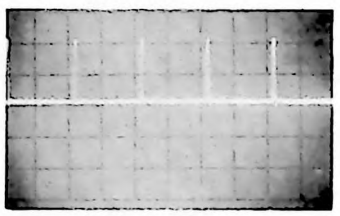
05221-D-2

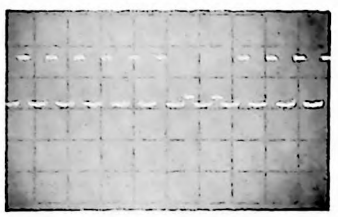
Figure 8-3. A1 Amplifier-Trigger



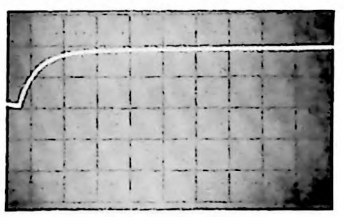
1 . 2 V/cm +slope
. 2 μs/cm



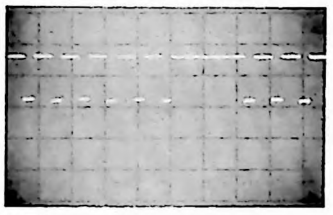
2 . 2 V/cm +slope
. 5 μs/cm



3 . 1 V/cm +slope
20 ms/cm

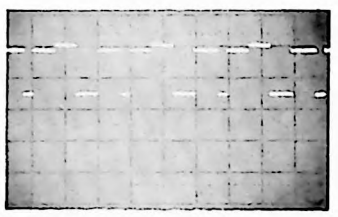


4 . 2 V/cm -slope
5 μs/cm

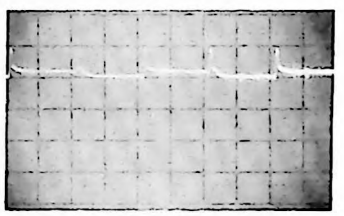


5 . 2 V/cm +slope
20 ms/cm

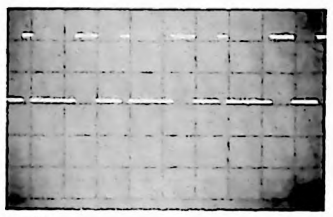
6 . 2 V/cm -slope
. 5 μs/cm



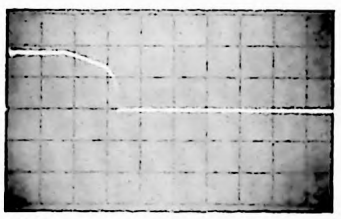
7 . 1 V/cm +slope
50 ms/cm



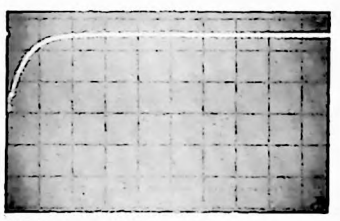
8 . 05 V/cm +slope
. 5 μs/cm



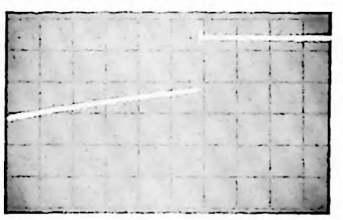
9 . 2 V/cm -slope
50 ms/cm



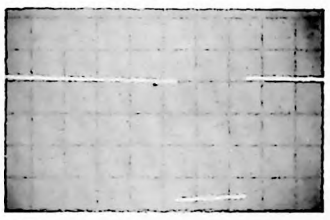
10 . 2 V/cm +slope
1 μs/cm



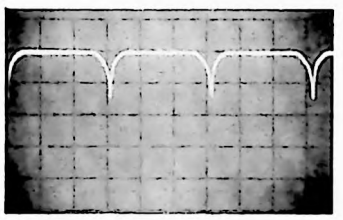
11 . 1 V/cm -slope
1 μs/cm



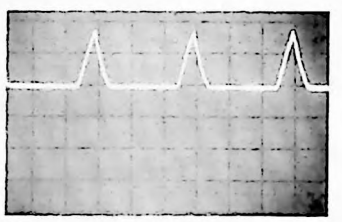
12 . 2 V/cm +slope
. 5 μs/cm



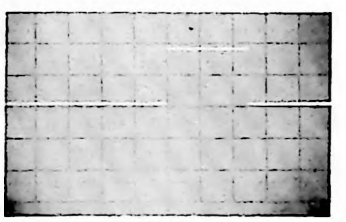
13 . 1 V/cm +slope
20 ms/cm



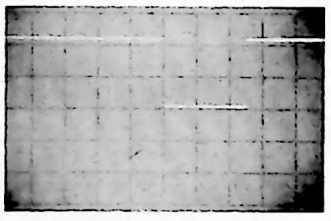
14 . 2 V/cm +slope
50 ms/cm



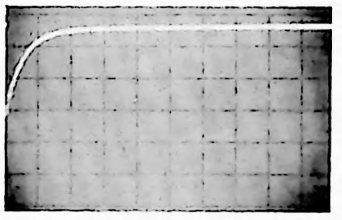
15 . 05 V/cm +slope
50 ms/cm



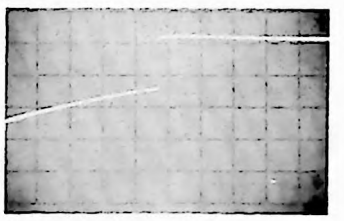
16 . 2 V/cm -slope
20 ms/cm



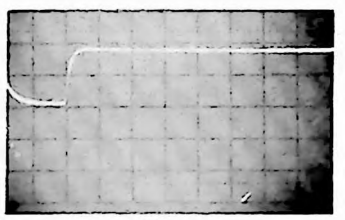
17 . 2 V/cm +slope
20 ms/cm



18 . 1 V/cm -slope
1 μs/cm



19 . 2 V/cm +slope
20 μs/cm

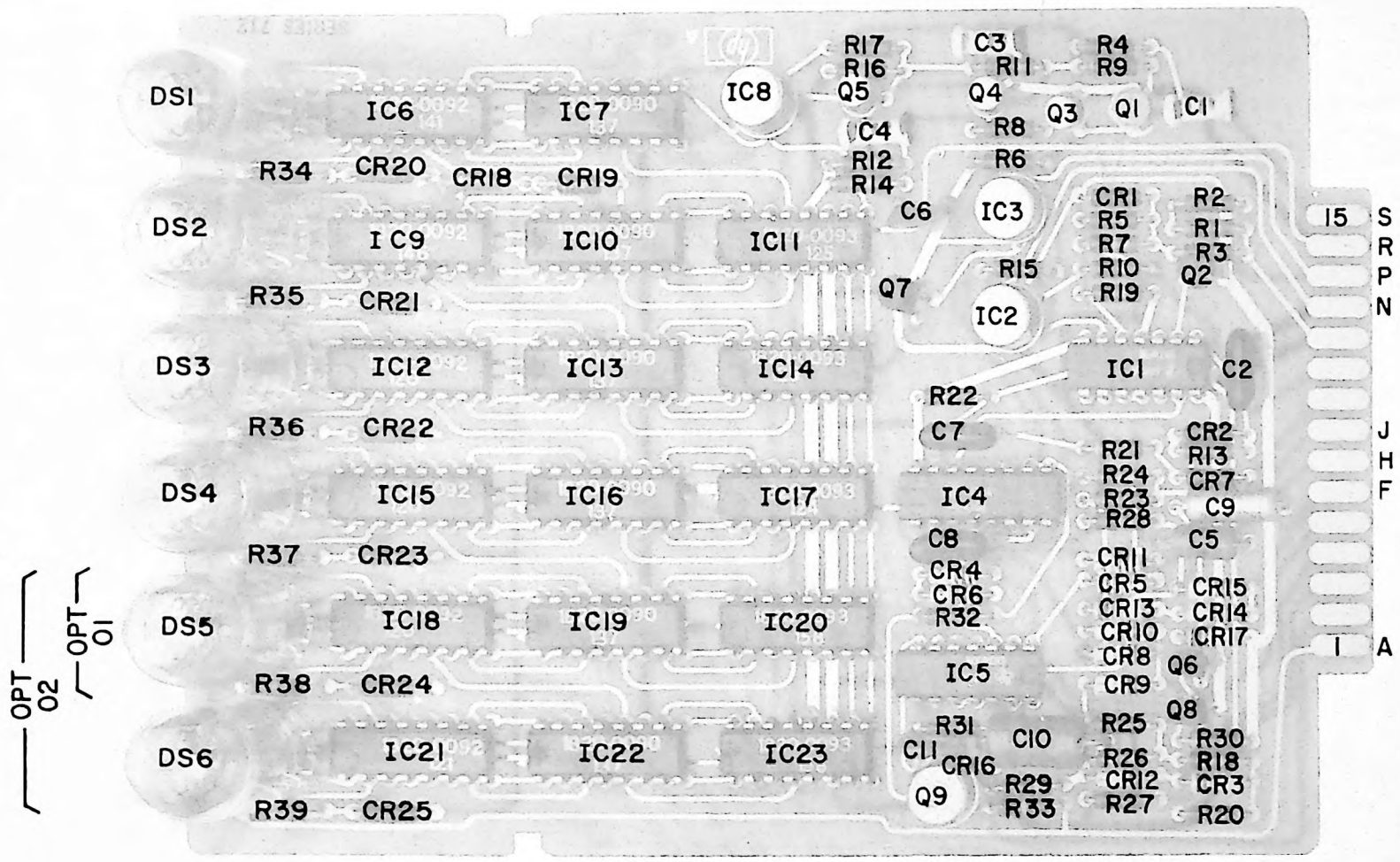


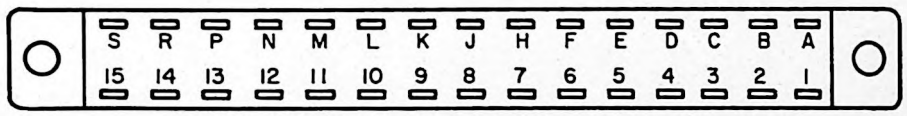
20 . 1 V/cm -slope
50 μs/cm

Oscilloscope: All waveforms dc coupled through 10:1 divider probe. Center line of graticule is zero volts. Triggering is internal ac.

Counter:

SENSITIVITY	clockwise with 1 MHz input
GATE SELECTOR	. 1 sec
SAMPLE RATE	counterclockwise not OFF





A2 CONNECTOR AS VIEWED FROM REAR OF COUNTER

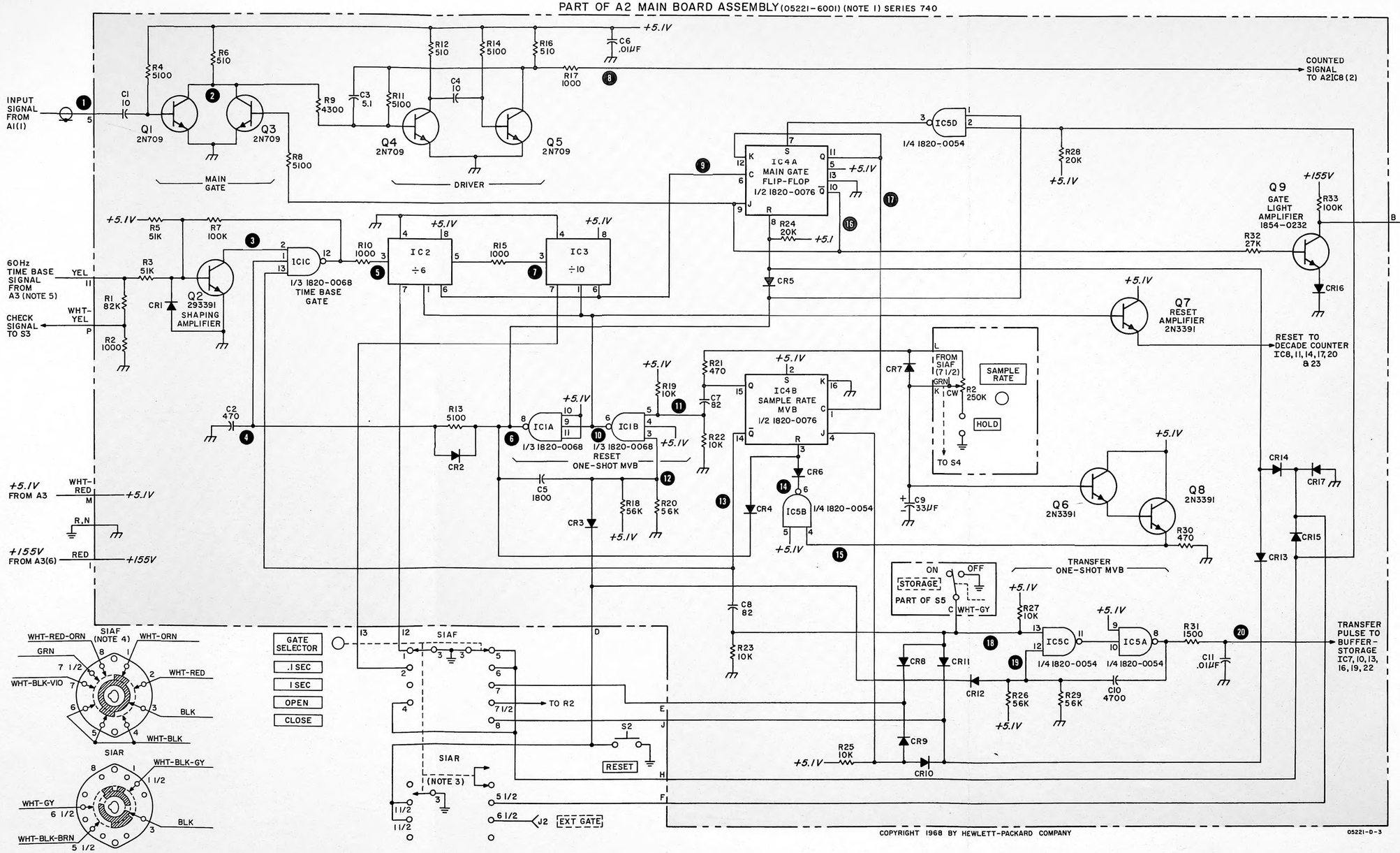
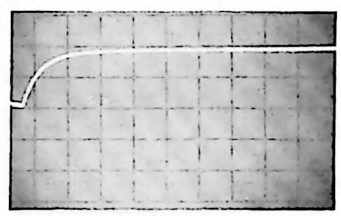


Figure 8-4. A2 Main Board
(Sheet 1 of 2)

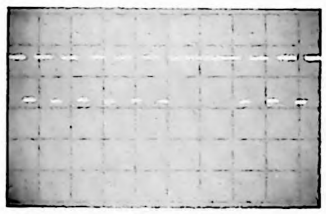
1 . 2 V/cm +slope
. 2 μs/cm

2 . 2 V/cm +slope
. 5 μs/cm

3 . 1 V/cm +slope
20 ms/cm



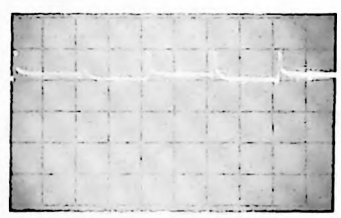
4 . 2 V/cm -slope
5 μs/cm



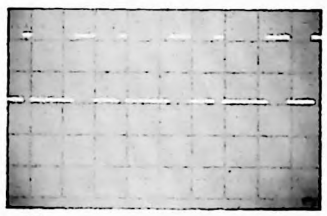
5 . 2 V/cm +slope
20 ms/cm

6 . 2 V/cm -slope
. 5 μs/cm

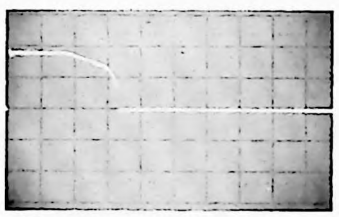
7 . 1 V/cm +slope
50 ms/cm



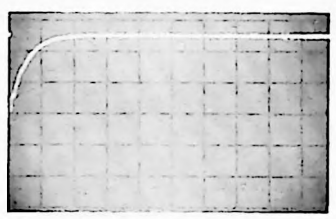
8 . 05 V/cm +slope
. 5 μs/cm



9 . 2 V/cm -slope
50 ms/cm



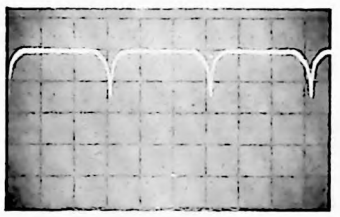
10 . 2 V/cm +slope
1 μs/cm



11 . 1 V/cm -slope
1 μs/cm

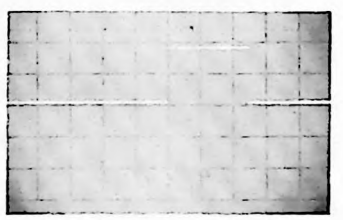
12 . 2 V/cm +slope
. 5 μs/cm

13 . 1 V/cm +slope
20 ms/cm

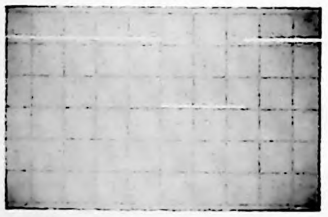


14 . 2 V/cm +slope
50 ms/cm

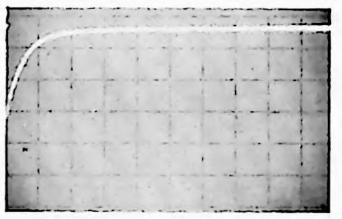
15 . 05 V/cm +slope
50 ms/cm



16 . 2 V/cm -slope
20 ms/cm



17 . 2 V/cm +slope
20 ms/cm



18 . 1 V/cm -slope
1 μs/cm

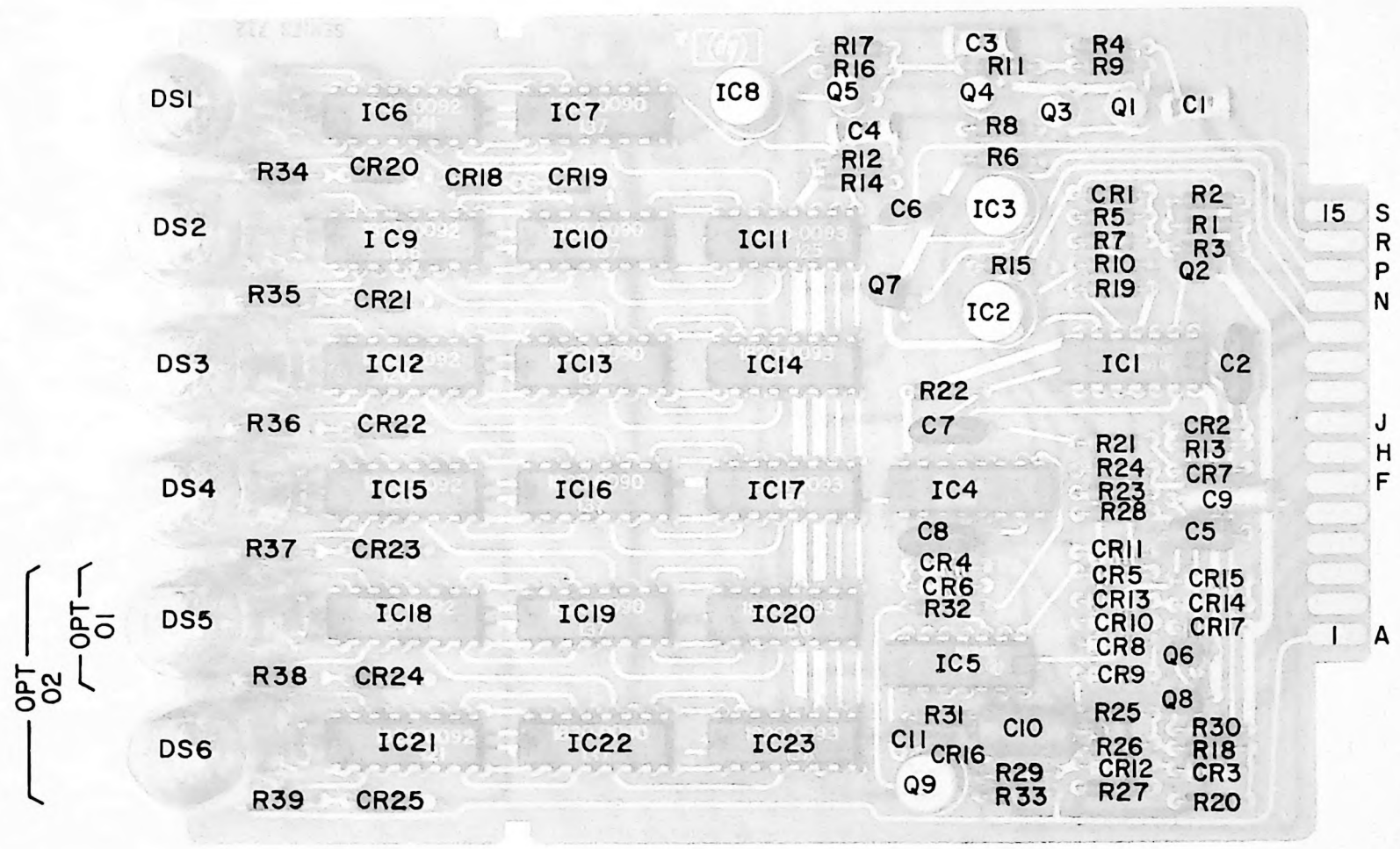
19 . 2 V/cm +slope
20 μs/cm

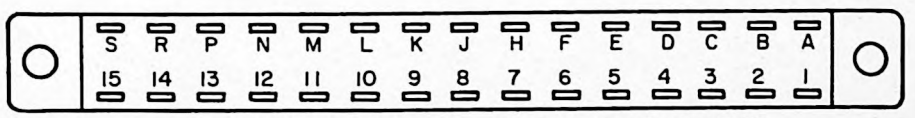
20 . 1 V/cm -slope
50 μs/cm

Oscilloscope: All waveforms dc coupled through 10:1 divider probe. Center line of graticule is zero volts. Triggering is internal ac.

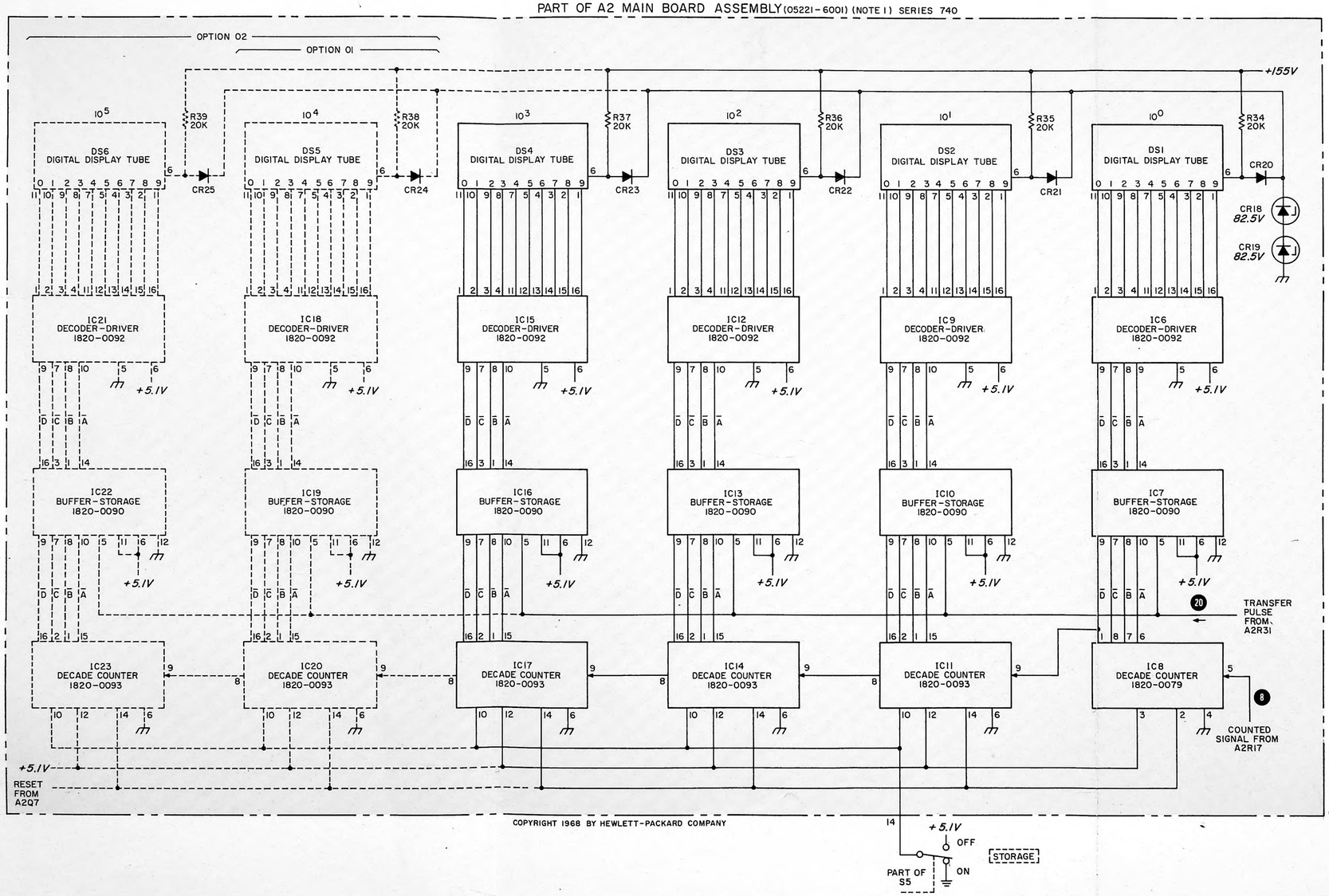
Counter:

SENSITIVITY	clockwise with 1 MHz input
GATE SELECTOR	. 1 sec
SAMPLE RATE	counterclockwise not OFF





A2 CONNECTOR AS VIEWED FROM REAR OF COUNTER

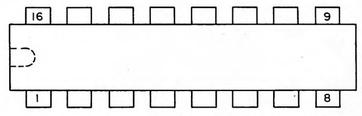


NOTES

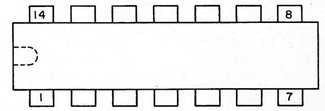
1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN PICOFARADS;
3. NO CONNECTION ON DETENT
4. SWITCH SHOWN IN MAX CCW POSITION
5. NO CONNECTION ON OPTION 10 INSTRUMENT

REFERENCE DESIGNATIONS

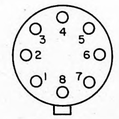
NO PREFIX	A2
DS1	C1-11 CR1-25 DS1-6 IC1-23 Q1-9
R2	R1-39
S1,2,5	



IC4,6,7, 9-23
TOP VIEW

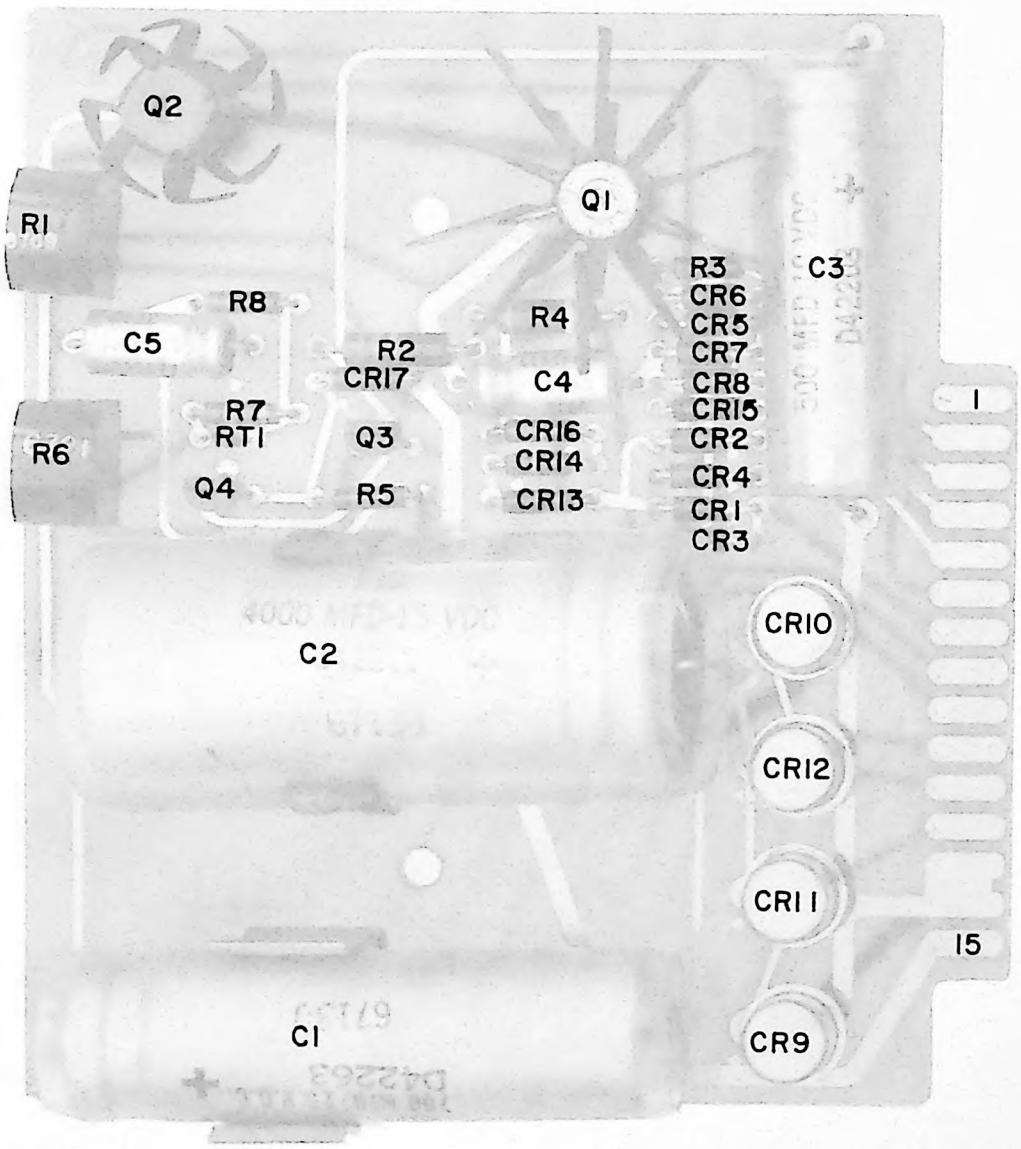


IC1,5
TOP VIEW

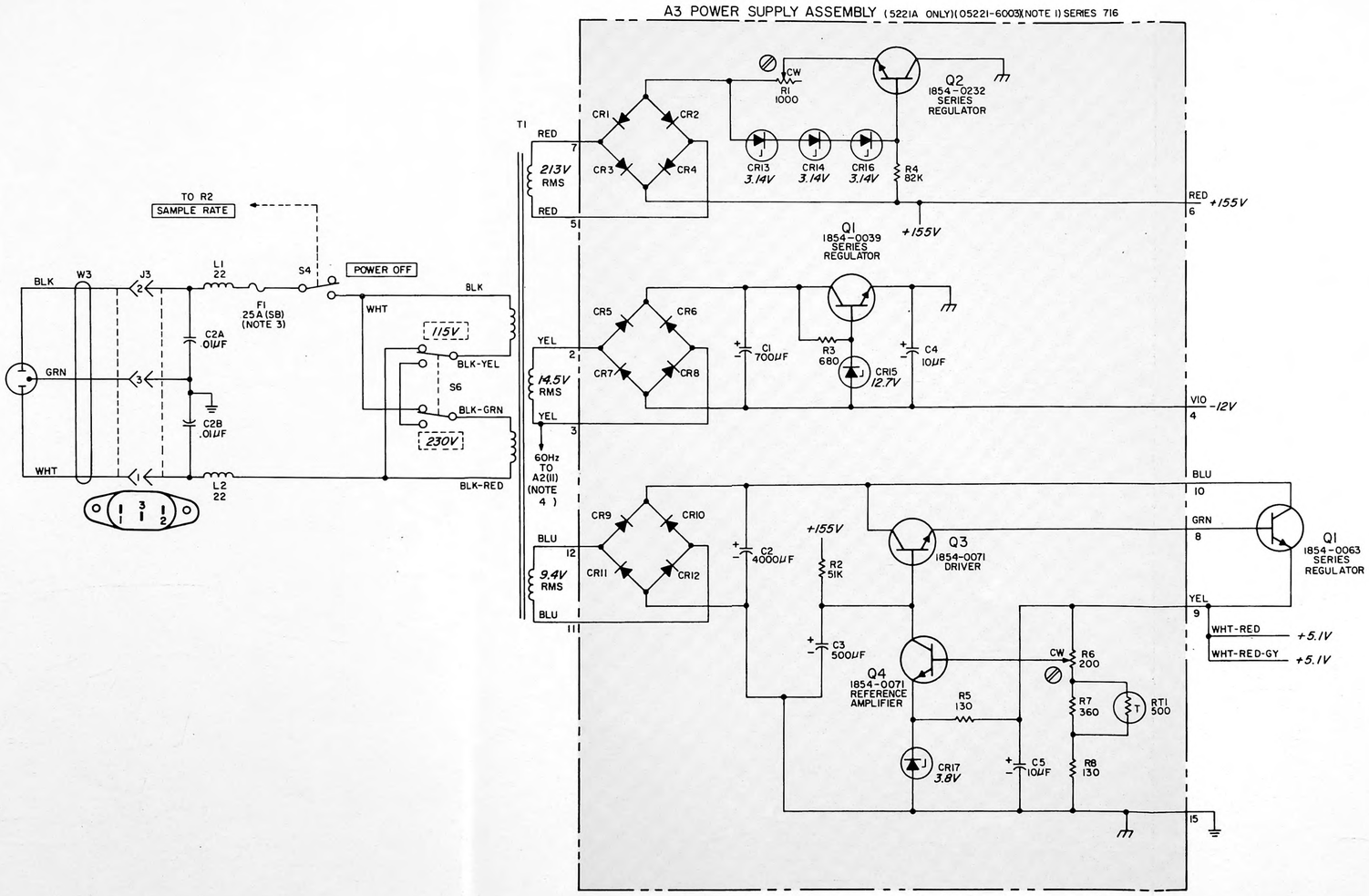


IC2,3,8
BOTTOM VIEW

Figure 8-4. A2 Main Board (Sheet 2 of 2)


Q2
Q1
R1
R8
C5
R2
CR17
R4
C4
R3
CR6
CR5
CR7
CR8
CR15
CR2
CR4
CR1
CR3
C3
R7
RT1
Q3
R6
Q4
R5
CR16
CR14
CR13
CR10
C2
CR12
CR11
15
C1
CR9

FOR 5221A



NOTES

1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN PICOFARADS;
   INDUCTANCE IN MICROHENRIES
3. FOR 230V OPERATION:
   SWITCH S6 TO 230V POSITION
   CHANGE F1 TO .15A (SB)
4. NO CONNECTION ON OPTION 10 INSTRUMENT

REFERENCE DESIGNATIONS

NO PREFIX	A3
C2	C1-5
	CR1-17
F1	
J3	
L1,2	
Q1	Q1-4
	R1-8
S4,6	RT1
T1	
W3	

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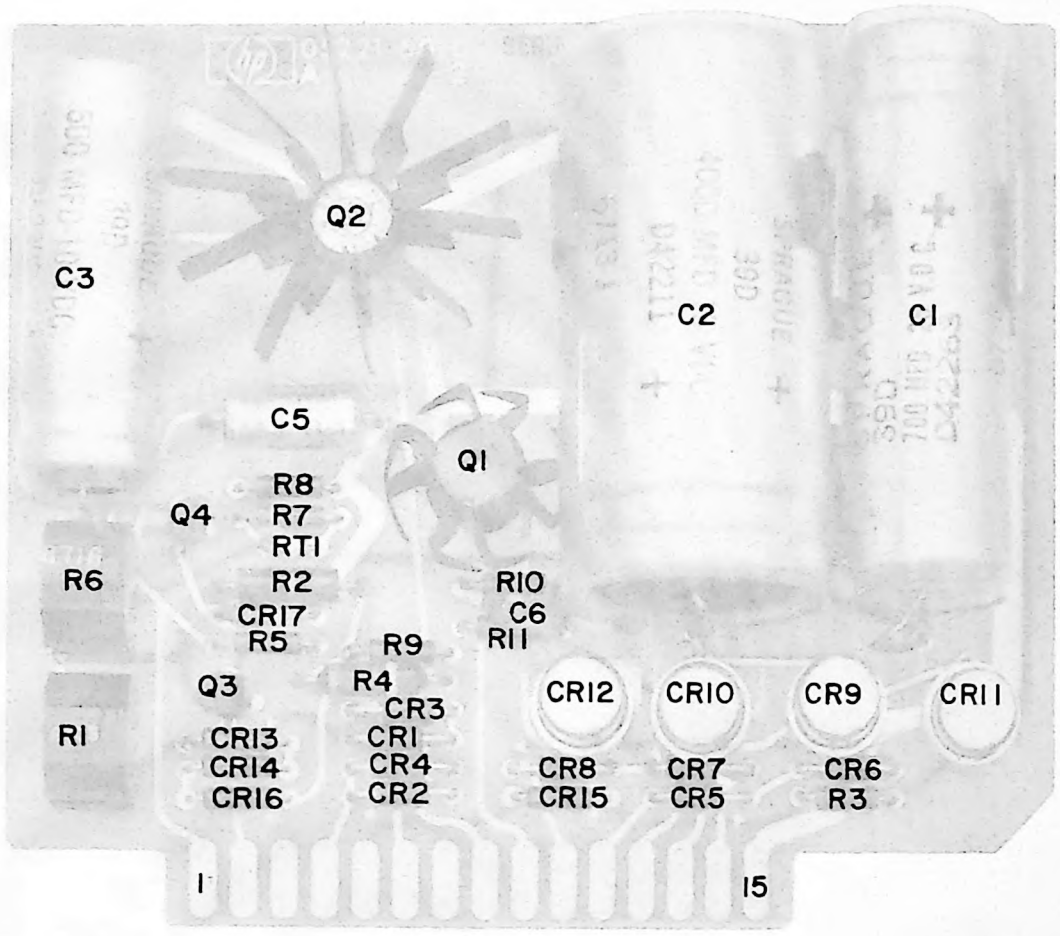
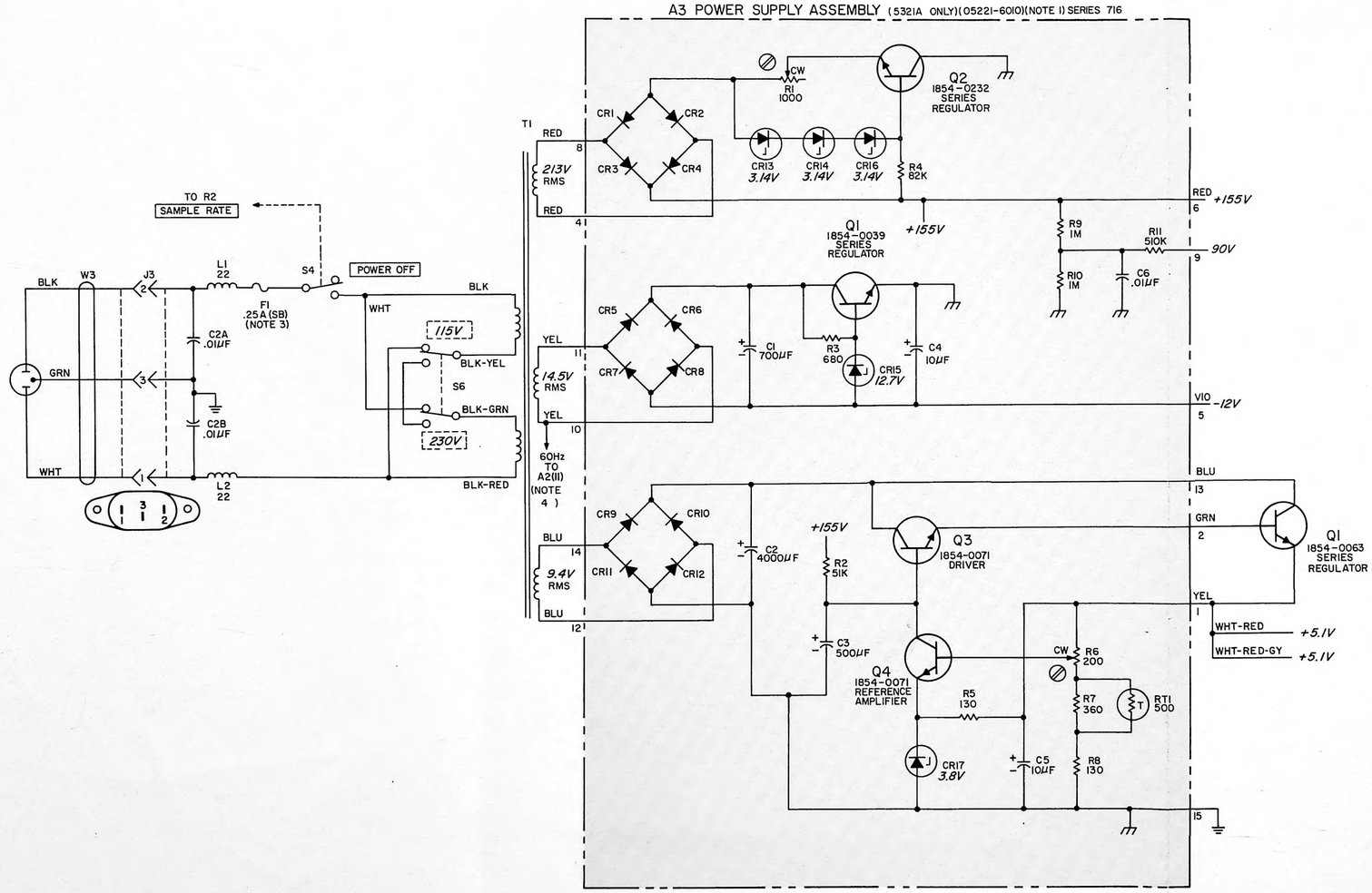
05221-D-5

Figure 8-5. A3 Power Supply (5221A)


Q2
C3
C2
C1
C5
Q1
R8
Q4
R7
RT1
R6
R2
R10
C6
CR17
R5
R11
R9
Q3
R4
CR3
CR12
CR10
CR9
CR11
R1
CR13
CR1
CR14
CR4
CR8
CR7
CR6
CR16
CR2
CR15
CR5
R3
1
15

FOR 5321A



NOTES

1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN PICOFARADS;
   INDUCTANCE IN MICROHENRIES
3. FOR 230V OPERATION:
   SWITCH S6 TO 230V POSITION
   CHANGE FI TO .15A (SB)
4. NO CONNECTION ON OPTION 10 INSTRUMENT

REFERENCE DESIGNATIONS

NO PREFIX	A3
C2	C1-6
	CR1-17
FI	
J3	
L1,2	
Q1	Q1-4
	R1-11
S4,6	RT1
T1	
W3	

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05221-D-6

Figure 8-6. A3 Power Supply (5321A)

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